Investigating Informal STEM Teaching and Learning In A Planetarium's Urban Youth Leadership Program

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THESIS

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SUMMARY

Science museums have become more inclusive and engaging to audiences, including the development of programming intended to reach wider audiences and provide more equitable access to science learning. However, how do educators and designers of these programs conceptualize equity? To explore this question, interviews with educators (n=6), student artifacts, and program documents were analyzed to identify the ways educators talked about equity in one out-of-school youth program created and implemented by a large, urban science museum. These discourses of equity fit into five categories: bridging in-school and out-of-school, community acceptance, infrastructure access, motivation/enjoyment and positive affective responses, and increase access for a select few.

Keywords: Equity, Discourse, STEM education, Out-of-School Learning, Museum Education

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CHAPTER I: Overview

Purpose of the Study and Author Background

This dissertation is an exploration of discourses of equity (Philip & Azevedo, 2017) related to one science museum's outreach program to urban high school-aged students. As outreach programming has become more of a defining part of what museums do, and in particular as museums have considered their outreach efforts as ways of expanding equitable access to museum resources, exploring the ways that educators talk about equity in their work in these programs can help practitioners and researchers better understand what equity looks like on the ground and how we might better support equitable access to science learning for young people. This is explored through a nine-month long study of students in a program at Science Museum (all locations and participant names are pseudonyms), in which students and educators reflect on their experiences. This dissertation is an exploration of a museum-school partnership that was designed to support young people in a large urban area (hereafter, named Urban Area) in developing applicable skills and in learning science content.

My own interest in this subject and subsequent study arose from my history as a learner and educator. As a child growing up in the Midwest, museums played a substantial role in my education. From making giant bubbles at the Curious Kids' Museum in Michigan to the wonder of crawling through an ancient Egyptian pyramid at the Field Museum when I was an elementary school student, museums were not only places to relax with my friends and family during the period I was not in school but also places for learning, especially when my own learning disability made nonverbal information a challenge to interpret successfully. As an individual with a nonverbal learning disorder, I often struggled with remembering sequences, especially if they were not visually represented to me. Meanwhile, when I was in museums, I found challenging patterns easier to understand--both because of the visual interpretations of information and the relaxed setting for learning. Indeed, these advancements were a far cry from the high-stakes testing that was beginning to crowd out learning opportunities in the schools that I attended in the Chicago Public Schools system.

I was not the only student who flourished while visiting these places of informal learning: siblings, classmates, and friends who were also dealing with trauma, disability, and other issues seemed to engage and learn more while they were in museums. Even as a youth, I began to wonder: Why did some of my classmates flounder on their biology and social studies tests in school but participated excitedly in field work with the Peggy Notebaert Nature Museum or hunting for archaeological remains at the Spertus Institute? These questions took a back seat, however, as I began college far away from my home city, at a university that was not urban, and whose student body was a departure from all that I had grown up with on the South Side of Chicago: wealthy, white, and West Coast.

I became drawn back to museums as an undergraduate at the University of Oregon, where I began working in collections in the coastal archaeological research laboratory under the guidance of Dr. Jon Erlandson. I loved the study of anthropology and the outdoors, which was a perfect marriage in Erlandson's quirky, waterlogged lab and in the natural beauty of the Pacific Northwest. Here, I found myself doing a wide variety of work as a research assistant, from cataloging shell midden to drawing shell pottery remains for reports. This experience, which soon led me to work at the natural history museum's lab on campus, brought me closer to the natural beauty of both the Willamette Valley in Oregon and the Channel Islands in southern California where our research took place. However, I soon found myself watching the elementary school and high school field trips that came to our lab, where we served as impromptu guides for the work and research that we did. Soon, I was transferred to the Museum of Natural and Cultural History's lab where students on field trips continued to visit. These field trips now also included Native American children for whom the museum's collections formed deeper and more meaningful connections among their culture, the oppression that their people had faced, and the resilience of their communities throughout the state and the country (Nagel, 1997). I threw myself into museum work and research, taking on my first formal education role as an assistant art teacher for the Jordan Schnitzer Museum at the University of Oregon until I graduated.

Six weeks after I graduated from the University of Oregon, I began graduate school at Southern Illinois University in their Public Administration program, the only program in the US at the time that allowed a graduate specialization in Museum Administration. This allowed me to take on many roles as a graduate assistant at the simply-named University Museum of Southern Illinois University, ranging from collections assistant to gallery designer. The question that I kept finding myself asking, though, was about the role that museums play in education. My research for my Master's thesis then focused on the role that the Southern Illinois University Museum played for the greater southern Illinois community, as it was often the first and only place that students in the area were able to visit on field trips.

The role of intergenerational poverty and opportunity to access museums for both schools and the general public was a concern I began to consider more carefully as I worked on my research regarding how this lone museum provided so much educational opportunities for both students and teachers within a large community. As a Chicago resident when I was growing up, I had taken for granted the many gifts that living in the city had given me, this equity of the opportunity of learning in different environments. I began exploring this role of access to museums again as I took a new position in education at the Lubbock Lake Landmark in Lubbock, Texas. Here, I was exposed to more research on science education, as faculty whom I worked with at Texas Tech University were researching the relationships of museums with local education and community (Genoways & Ireland, 2016).

My last year before starting a doctoral program, I took a position as an AmeriCorps staff member as the education coordinator for a museum in a rural part of the Pacific Northwest, and serving as an educator for the Salmon-Trout Education Program (STEP) that brought hundreds of school children to fish hatcheries throughout the Cascade mountains. For the vast majority of these students, according to the director and community members whom I worked with closely, this was their first and only experience of learning about science outside of their school classrooms. Research has shown science education to be supportive when students are working alongside researchers, and the students that I worked with outside of the museum reacted well to these opportunities to learn (Unsworth et al., 2012). By this point, I had seen many different instances from across socioeconomic, ethnic, and geographic boundaries that pointed to the same insight: museums and informal education experiences positively transformed students' experiences and perceptions of school subjects (Yoon et al., 2012). But how could I investigate these positive transformations that I could so clearly see as an educator in Illinois, Oregon, Washington, and Texas?

After many years of working in informal science education throughout the United States, especially with youth disadvantaged through both economic and learning differences, I saw museums as less of a place of recreation and comfort, and more of a substantial space where students who were in poverty and/or had learning disabilities were able to see the beauty and wonder of their planet. How these informal learning environments were connected to educational experiences of the audiences that visited them was the research question I asked as I began work at the Learning Sciences Research Institute as a doctoral student in the Learning Sciences in 2012. I also found myself asking these questions as I took up work as an evaluator at the Science Museum in Urban Area (the museum that I worked at and where I conducted research and the urban area where it is located are given these pseudonyms throughout the remainder of this dissertation). At the Science Museum, I began working with programs and students who came in from all walks of life throughout the Urban Area to engage with physics and math through experiments that they tested and the volunteering they did in the museum. That led me to wonder what role museums can play in the learning pathways of these students. How are we seeing museums supporting learning opportunities? Most of all, were these opportunities expanding equitable opportunities for young people to learn science, as not everyone had the experience that I had with museums as a young learner? I wanted to investigate teaching and learning in museums in ways that I would be able to hear not only the human stories behind teaching and learning experiences but also better understand how museum programs supported learning opportunities for young participants. Because of my relationship with Science Museum, I was able to pursue my questions by studying one museum program--the Science Leadership Program at Science Museum.

The Science Leadership Program at Science Museum

The Science Leadership Program (SLP) at Science Museum was designed to combat barriers of access to and participation in experiential STEM learning. The Science Leadership Program was also designed to provide additional opportunities for marginalized students in the city of Urban Area. The Science Leadership Program was developed by Science Museum educators for older teens in Urban Area to give them mentorship as leaders and more experiences with STEM learning. For many of these students, this was not only their first experience working closely with science and engineering as young professionals, but it was also a first-time experience for them working with a museum as their place of employment, and therefore the program had the possibility of shifting their perceptions about who museums were for from a professional perspective, such as an astrophysicist or a product engineer, roles that require high amounts of education and perseverance to obtain. In the Science Leadership Program, students were given the opportunity to both work and study at the Science Museum, experience different leadership roles at the Science Museum ranging from research to education, and through these experiences gain an understanding of the work that is conducted at both the Science Museum and other science centers around the world.

The Science Leadership Program was the evolution of a new series of direct programs for youth designed by Science Museum educators for high school students in Urban Area that had started years earlier through a partnership with one high school, and had spread to include more. This is common in many museums, where the need to become more of an integrative part of a city's identity, especially for youth who may otherwise feel unwelcome or excluded in museums, is more central to a museum's mission. While many museums have reached out to youth through programming and other offerings of agency, such as the formation of teen councils and free tickets for youth participants, few offer career training and in depth learning (Kisiel, 2006a).

What would become the Science Leadership Program started in the summer of 2014, and continued through the 2014-15 school year. During the school year, students were given professional development through training and hands-on leadership activities in settings both at the museum and at local meeting places. These activities were funded by a grant from an Urban

Area learning network in May 2014 and supported by Science Museum and SSN, an Urban Area-based non-profit that provides paid work opportunities for young people.

I was hired as a paid evaluator of the Science Leadership Program based on my previous research evaluating the Science Museum/Selective Enrollment High School program during the 2013-14 school year, a different program run by Science Museum that came before the Science Leadership Program. Science Museum needed someone with a background in both urban education and museums, and I happened to fit their needs with my experience. During this time, I was the only evaluator for the Science Museum's program, which worked well for my work in Curriculum Studies in the department of Curriculum and Instruction at UIC, where I was focusing on not only the different aspects of learning, but also on young people's learning. I had changed doctoral programs to Curriculum Studies after one year in the Learning Science doctoral program, when my research interests changed from understanding the technologies found within museums to considering the learning of people who visited museums.

While I was an evaluator of the program, I had permission from my employers at the Science Museum and from my doctoral advisor at the time in the Curriculum Studies program at UIC to pursue my own research related to the Science Leadership Program. As a result of my research interests, I set out to study student and educator engagement at the Science Museum over the course of a year. While I did have direct orders as to how to complete the evaluation, I was also responsible for designing many of the qualitative aspects of the study that would address my research question for this dissertation. I collected data for this study during the 2014-2015 school year from these students and their instructors over the course of a year at the Science Museum's Science Leadership Program. The program was developed to expand on the partnership between public high schools in the city of Urban Area and the Science Museum, which had a successful first year partnership with a select-enrollment Urban Area public high school.

The study included data collection at the beginning of the program (July 2014), at the middle when the program was in full swing (November 2014), and at the end of the program, when students were concluding their experience with Science Museum (May 2015). Additionally, I considered the background and teaching methods of the Science Leadership Program instructors in order to investigate the instructors' roles in supporting student engagement and learning. Their backgrounds and teaching methods were explored through interviews and through the reports that they gave, though no observations were made.

Why Out of School Learning and Equity

In this study, I am focusing on the role of out of school learning in terms of equity and how equity is understood and interpreted by both the Science Museum and the educators that led the Science Leadership Program. To investigate how the Science Museum and the educators understood equity, I will analyze interviews with program educators to consider the discourses of equity. The concept of discourses of equity, meaning the way that people and institutions talk about equity, I draw from Philip and Azevedo (2017). With Philip and Azevedo, I hope to "uncover some of the key assumptions about equity and the 'theories of change'" (p. 528) in the ways that the Science Museum and program educators talked about equity. This is important as with the rise of STEM education and opportunities for out of school learning (Sanders 2009), how programs conceive of equity can vary widely depending on both the interpretation of equity and execution of the program. This is a matter that is important for all that are concerned with this form of education, ranging from educators to administrators, from the parents and students who participate in programs like this, and those who do not have the opportunity to participate.

Why I Wanted to Study This

I wanted to study out-of-school learning because when I was a participant, as well as an early-career professional, I understood it at the time as a truly equal form of education. This perspective changed after my experiences in the informal learning field, and now as a professional and doctoral candidate, I understand the different issues at hand in regards to equity and access. I was under the impression, years ago, that anyone who entered a museum would receive an equally comparable form of education, regardless of race, creed, or socioeconomic status. Now, I recognize that access to museums is an issue for many members of society, even though there is much in terms of inclusive work that many of these institutions are doing now. These issues of access include distance to attend the museum, cost, and time spent at these places, as well as linguistic, social, and emotional factors that can prevent many people from museum participation. Some of these factors are political and historicized, and addressing them is not just about increasing access. While museums want to expand their civic and educational footprint, and include this in their mission statements, there are significant challenges to equity and access to learning opportunities in museums.

An Example of Why This Is Important

When a museum's civic, cultural, and educational impact is diminished, there are consequences for learning. I witnessed this in 2017, when the museum I had written about and worked in for my graduate degree in Public Administration, the Southern Illinois University Museum, was shuttered by the state of Illinois during a state budget impasse that caused intense issues within publicly funded institutions. As a result of the budget not passing, there was not enough to keep the museum open during this time, and it closed in mid-2017, despite the protests of many at the university and the greater Carbondale, Illinois, community. This was the only natural history museum in a multi-county region in the rural Midwest, and as a result, hundreds of students could not attend the many field trips designed for them by the university staff and graduate students at Southern Illinois University. While this may seem histrionic by other pressing issues at hand in the State of Illinois at the time of the budget not passing during Bruce Rauner's tenure as governor, this was the only chance that these many students had to visit a museum and engage with historians and graduate students who were very knowledgeable about the subjects that these students were to learn about. Learning that should have occurred did not, and issues regarding equity and access such as this were brought up in the discussions that happened after the museum was reopened in 2018, when the state budget was finally passed. With this being stated, even once the museum was reopened, there are ongoing issues of equitable opportunities to learn.

As a result, this work is crucial to me as a director of an out-of-school STEM program, where I write curriculum, oversee educators and volunteers, and conduct evaluations of the students' and teachers' experiences, especially as I work to create programs to practice more aspects of diversity and inclusion, and to address broader systemic and historic inequities. Understanding the important role of out-of-school learning is necessary in order for museums to support all people who do and don't walk through their doors, that these people may learn and enrich their lives. Which leads to the questions then of equity and out of school learning, as I saw that the way educators spoke about equity and access in ways that sometimes were different then their stated goals in the Science Leadership Program.

I came into my role as a researcher exploring the leadership program with an understanding that the people who ran the program intended for it to promote access to the museum and to learning opportunities. However, I saw that the way educators actually talked about equity and access sometimes aligned with their stated goals but sometimes were quite different. Philip and Azevedo (2017), as a result, gave me a way to talk about the ways that these educators said they wanted to address inequities.

Defining Discourses of Equity

Philip and Azevedo (2017) point out the fluid conception of equity in everyday science learning, which they call ‘a moving target, shifting in meaning across contexts’ (p. 526). Observing this somewhat arbitrary definition, Philip and Azevedo present four discourses of equity. Understanding how educators talked about equity and the different facets within the program that took place required a better understanding of the framework laid out by Philip and Azevedo. In this piece, Philip and Azevedo wrote that their “intention [was] to uncover some of the key assumptions about equity and the ‘theories of change’ prevalent in out-of-school science learning scholarship” (p. 528). In this case, I considered the ways in which educators within this particular program in Urban Area spoke about equity.

Goals of the Science Leadership Program

The goal of this program was to create in-depth experience within science and engineering, as well as nurturing leadership skills amongst youth within the Urban Area. According to the program hosted at the Science Museum, it was designed to give participating high school students a “yearlong professional development through training and hands-on leadership activities in diverse settings,’’ with the inclusion of “improvement to student use and knowledge of applied science and increased independence and leadership skills” (Summative Report, 2015). The Science Museum stated that this program was meant to help students with both training and hands-on leadership in diverse settings. The Science Museum stated that they hoped this program would increase equity through the students’ opportunities of professional development and skills that would make them a valuable asset to society. To quote the Science Museum's summative report on the program, "The main objective for students within the [Science Leadership Program] throughout the duration of the year-long program was to design and build their own balloon-borne near-space science experiments with the guidance of both Science Museum and [program] staff. The students would then launch their experiments to near-space (approximately 80,000-100,000 feet in altitude), retrieve them, analyze the subsequent data, and present their results to peers in the same manner a scientist would."

Based on their description, although equity was not the outward defined goal of this program, it is clear that Science Museum defined equity as giving students professional and educational skills that would include both research skills and leadership abilities, both of which would lead to eventual workplace readiness. In this case, equity as a result is defined through personal growth that could, potentially, end in economic and educational growth for both participants and greater society.

Using Philip and Azevedo's Categories of Discourses in Analysis

When the goals of this program were stated in the summative report released by the Science Museum, it is clear that they were thinking about equity in a particular way, as described above. In my study, I will use Philip and Azevedo's four categories of discourses of equity, to consider how educators working in the Science Leadership Program talked about equity. Here, I briefly identify each of those four discourse categories with their associated benefits and blind spots as described by Philip and Azevedo: 1) "out-of-school science can be an important bridge for school-based science learning" (p. 528). Educators utilizing this discourse believe that students who participate in out-of-school learning will have better access to school-based science learning, what Philip and Azevedo, citing Delpit (1995), articulate as a "culture of power."

However, this discourse narrowly addresses access without considering broader equity issues. 2) “Out-of-school science offers more authentic and expansive forms of learning in comparison to most school-based science” (p. 528). This means that doing science out of school can afford more real-world experience with scientific practices. While Philip and Azevedo note that this discourse supports students in developing identities as doers of science, it is also focused primarily on access and thus ignores systemic issues related to the underrepresentation of people of color in science. 3) “Out of school science can change what is valued in school-based learning and professional contexts” (p. 528). In this case, it means the field of science can be changed by student participation within the out of school experience. Philip and Azevedo also note that the challenge of discourses of equity is that the field of science is deeply embedded in an ongoing social hierarchy and including that of political and economic interests, citing Harding (2006) and Nader (2006) in regards to this concept. 4) “Out of school science in justice movements offers new possibilities to understand the relationship between science, equity, and justice” (p. 529). This discourse addresses the possibility that social change begins with community organization and social justice, using science as a tool for it. Philip and Azevedo then note that science, in this discourse of equity, is not privileged but, instead, citing Harding (1992), “the epistemological and ontological assumptions in science also make scientific knowledge partial and incomplete” (p. 529). And therefore, science is a tool, like others, for engaging in social change. In order to explore what educators mean when they talk about equity in the out-of-school science program they’re affiliated with, in this case the Science Leadership Program, I will use Philip and Azevedo’s framework.

My Study of Discourses of Equity

My study uses this framing to consider assumptions about equity and theories of change at the ground level—namely, among educators who work in out-of-school science programming. As a result, I focus on interviews with these science educators who worked in one museum-based program to explore how they conceptualized equity in Urban Area. In analyzing these interviews, I ask the following: What did equity mean to them in the program? Did they think and talk about equity in the same way that Phillip and Azevedo say scholars think and talk about equity? Finally, how do their conceptions of equity guide the way they talk about the program they're involved in and their own teaching practice?

Why This Work Matters

This work matters due to an ongoing need for these opportunities to be available for all in science education, in addition to the need to address historical and systemic inequities. An additional reason that this work matters is because science educators are engaging with youth in contexts that make the claim that they provide equitable learning opportunities. But what do they mean by equity? How do these programs perpetuate inequities?

Research Question and Study

For the purposes of this dissertation, the research question I asked was the following:

- **In a museum outreach program intended to support equitable science learning, how did program designers, educators, and youth participants conceptualize equity in their discourse?**

In introducing my study, I explore how science education evolved alongside a changing American society and culture, leading it to its current role as a necessary, but often embattled, subject in schools throughout the United States. I will also consider the concurrent role of museums in this evolution. In chapter 2, I will explore the history of science education and its intersections with equity through a review of the literature, starting with the history of museums and education of science, including considering the different forms of equity and how they are interpreted and used in informal education to this day. This will also delve into the aforementioned authors' idea of equity and how they could be discussed by others in different modes of education. Next, in chapter 3, I will describe the methodology for my research study, including how the data was collected and analyzed utilizing the framework of discourses of equity, which I borrow from Philip and Azevedo (2017) and Dawson (2014). In chapter 4, I will share the analysis and findings. Finally, in chapter 5, I will conclude and discuss implications of what I have found during this course of study for research and practice.

CHAPTER II: LITERATURE REVIEW

Overview

In this review of scholarly work, I will explore research regarding teaching and learning and equity in museums. In addition to this, because my dissertation study explores discourses of equity used by out of school educators who are participating in a program ostensibly intended to expand equity for young STEM students in Urban Area and, in order to think more broadly about equity in out-of-school science learning programs, in this chapter I will review literature about learning in museums and their outreach to new audiences through education.

As mentioned above, the literature I review will include a brief overview of museums and their development as places supporting equitable access to science learning. I will also review literature about science learning in and out of schools. First, I will discuss museums in the United States, with a focus on their efforts to expand programming in order to support what they saw as increased access and equity around science learning. In particular, I will attend to the history of museums in teaching science and identify some of the important barriers and opportunities of museum science programming for different learners. Because my study involves a particular kind of museum--a Science Museum--I will conclude this section of the literature review by discussing the origins of science museums and how they have seen themselves as playing a role in expanding learning opportunities for students and audiences throughout the world (Bailey & Slater, 2003).

In order to connect museum education to science learning in urban settings, I will briefly discuss the history of science education in schools situated in cities. Throughout the dissertation, when I use the term ‘urban,’ I am defining it from Milner (2012) as “used to describe school contexts that are concentrated in large, metropolitan cities across the United States” (2012). I will consider both challenges and opportunities for teaching and learning in science education. This literature review will conclude with a consideration of discourses of equity in science education and the subsequent role that museums can play in expanding equitable learning opportunities, drawing from both Philip and Azevedo (2017), and Dawson (2014).

Science, Museums, and Society

In 2018, many schools find themselves scrambling to produce adequate science learning opportunities for American students, which includes more challenging curriculum, more lab equipment, and more diversity in subject matter for students to gain hands-on experience, such as robotics and coding (Castleman et al., 2018). These changes, as mentioned throughout this paper, have been part of American classrooms and curriculum in the hope of some that this will turn students into employed and educated professionals who would keep the United States at the front of the world economy. The roots of this development are arguably not new, with their development happening during the Cold War when Soviet and other communist controlled countries were perceived as having superior student achievement in math and science (Kliebard, 1999). This insecurity among some in the US of student achievement in the areas of math and science meant that education leaders pushed for greater expansion of the education of the subjects in and out of school, a heritage that continues to this day with concerns of American students entering the workforce with less skills than their international counterparts in science and technology (Castleman et al., 2018).

This concern, stated by Castleman and other scholars, including Maltese and Tai (2011) is focused on the performance and prospects of Americans careers and post-secondary education. Preparing American students for the workforce goes beyond expressed desire for changes to traditional classroom instruction, especially in an era when educators and policy makers call for constant learning (Falk & Dierking, 2018), including encouraging young people to participate in educational activities outside of school. There has been a steady increase in student participation in out of school learning programs since the 1960s (Badura et al., 2018). Out of school learning in this dissertation is defined as all education outside a traditional school classroom, which includes museum education.

In writing about museum education, I mean programs and visits rather than school-time field trips. This role of the museum as public learning space has gained ground during the early 20th century, as many cities expanded, while hosting and creating large museums for larger public audiences (Dodd et al., 2010). In order to better understand this role that museums and their out-of-school programming can play for young people, we need to better understand where museums come from in the first place.

Museums, Their Origins and Equity

Curiosity, and reverence for the past, can arguably be called universal traits amongst human societies (Litman, 2005). Nowhere is this viewpoint more poignant than in the creation of the museum, found in numerous cultures across the world, to preserve artwork, scientific specimens, and other collections to both keep the items in good condition and to tell a narrative of their existence (Boswell & Evans, 1999). Museums, ranging from art to natural history, were often created by wealthier individuals as a form of collections of art and artifacts by and for wealthy and powerful people. Early museums in human history ranged from collections of artwork by European nobles, to the collected gardens of Assyria, to the zoos kept by Aztec emperors before the conquest of the Americas (Glassberg, 1990). Collectors of these items generally assumed that the audience who would attend these galleries and observe their collections would be patrons of a similar class and educational background.

Conversely, other ancestors of modern museums that were more lowbrow were simply forms of entertainment, such as sideshows of anatomical or natural collections of specimens, often traveling from town to town as part of a traveling circus or other mobile attractions (Adams, 2001). While this differed from most museums designed by the rich to showcase a personal collection, museum and sideshows had the common theme of education and entertainment, including the aspect of displaying something exotic from far away or rare. Although the vast majority of museums were founded as collections for preservation and display, many museums began to evolve in their engagement with the public in the 20th century, with the shift happening during the Industrial Revolution, when there was both more leisure time for greater society, which arguably included a need to showcase Western power in public, highly trafficked places, such as the Columbian exposition (Rader & Cain, 2014). Subsequently, museums also began establishing education departments for more in-depth experiences for visitors, including training both volunteers and paid instructors to teach their curated pedagogy to students and other members of the public who visit museums (Falk & Storksdieck, 2009). Because of the nature of museums, many learning activities became housed in these locations, though their history of engaging the public has evolved just as traditional schools have. The dedication to educating a large public still had a role to play in the design of the museum as a learning space, as seen through the changes of education, display, and audience engagement (Schwartz, 2005).

However, as museums in the United States evolved alongside American culture in the 20th century, changes in social awareness meant that curators updated the vast majority of exhibits, especially within science museums, as well as expanding this offering to students and schools who may not have previously been able to participate in these programs (Schwartz, 2005). For many science museums, such as the Oregon Museum of Science and Industry, have changed both their exhibits and their messages, and now include a much stronger message of inclusion (Dierking et al., 2006). Museums have continued to change, and during the end of the 20th century became more of a place to learn for multiple groups of the public. This shift towards expanding opportunities to learn for larger audiences has arguably led to museums being seen as both relevant and culturally acceptable to contemporary visitors. Preservation and displays still serve a role in museums, but many museums have begun to pay more attention to the experience of the visitor, and the development of educational programming has become more important to carrying out the mission of museums (Gutwill & Allen, 2012).

These changes in museum design and education towards expanding opportunities to learn also included Science Museums, a subset of museums that focuses on stellar bodies and the Earth's sky, as well as the science and human history behind their collections and exhibits. In the section below, I consider the specific history of learning in Science Museums.

Science Museums: A History, A Science

Science Museums developed from humanity's desire to better understand part of their world—in some cases, the celestial bodies that filled the night sky, how machines work, or how the human body has evolved on a molecular scale. As long as there have been stars above the earth, there has been curiosity among humans to study them, as well as other natural phenomena in our world (Bailey & Slater, 2003). Anthropologists believe that observatories, which were created to better view the stars with the naked eye and to understand the stars' placement within the greater universe, began as early as 5000 B.C.E., through the construction of sites such as Stonehenge in what is now the United Kingdom and Zorats Karer in modern Armenia (Bailey & Slater, 2003). Cultures throughout the world have attributed various deities and mythologies to the stars, often using the aforementioned observatories at ancient temples and other worship sites to observe and contemplate them (Bailey & Slater, 2003).

These observatories--places used to chart out and explain stars, which included observing celestial bodies with the naked eye, eventually evolved in to places similar to museums, as more knowledge and interest eventually centered around the development of institutes to better study these celestial bodies and the sciences within them. This included the technologies that helped explore them, namely telescopes, and helping visitors understand the complexities behind space, using exhibits and shows about the celestial bodies such as the solar system and surrounding galaxies. Thus, one version of the Science Museum was born, evolving alongside science education in schools as the Space Race and the subsequent public interest in outer space and advanced technologies during the middle of the 20th century (Rudolph, 2005).

Science Museums and Equity

The challenges for many museums in the 21st century in the United States are also seen to an extent within a science museum's walls. While science and hands-on museums that focus on engineering, astronomy, and other 'hard' sciences in general have not had to deal with social and political issues that many art and science museums have faced due to their lack of focus on biological or cultural specimens (unlike museums specializing in subjects such as art and anthropology), the common social issues that have faced museums have been seen at modern science museums and planetariums as well. This ranges from a lack of diversity among its staff, the vast majority of whom are white and upper middle class (Gledhill, 2012), to the need for greater reach of the museum's educational mission throughout underserved areas in their surrounding communities. This means not only creating engaging exhibits that are better equipped to explain complex issues of celestial origin to visitors of all backgrounds, but also expanding the diverse body of people who staff it.

Unlike many of their museum counterparts, many museums that focus on science and engineering have been fairly, if not arguably, quiet on the social change that has driven other museums during the ‘Occupy Museums’ movement, as well as the call to diversify the staff and visitor populations of other institutions in the last dozen years (Schwartz, 2005). Part of the issue, arguably, is the fact that these institutions’ subject matter is not traditionally human or even Earthly based, in the case of many planetariums and observatories. While many science museums touch upon society or human involvement in the sciences, the focus has historically not focused on a social story, or scientific matter that may have been clouded by racism or Western imperialism. This has not stopped many science museums from addressing the need to tell the stories of professionals who have helped shape the world of astronomy today.

Another issue that ties into the history of racism in the sciences is the historical lack of diversity in the profession of researching engineering or space. Similar to the history of science, when non-male, non-white people participated in contributing to technology or science, it was out of view from the public eye in a less open, visual role, such as serving as a computation professional (otherwise known as a ‘computer’), and facing layoffs when technology created machines that could do these jobs at a faster, more efficient pace (Parasuraman & Riley, 1997). Though they contributed, women and people of color were often not credited or seen as the ‘face’ of these discoveries when they were published or presented to the greater public. Indeed, it was not until the space program reached the 1980s when the first African American astronaut went into space (Garcia, 2007), and the 1990s when the first Latinx American was selected to be an astronaut by NASA (NASA, 2018). This presents a subsequent challenge when visitors are directed to the historical exhibits of the Science Museum that was the subject of this research, where they see pictures of white scientists, engineers, and astronauts.

Seeing others like themselves is a powerful experience for many audience members who attend museums. This sense of inclusion is a unifying feeling for many individuals within astronomy and space exploration, including those who participated in such amazing events as recounted in such films as *Hidden Figures*, which told the story of African-American women in creating the foundations for the NASA space shuttle program. To quote one of the computers, Katharine Johnson, in an interview with WHRO-TV, “I didn't feel the segregation at NASA, because everybody there was doing research. You had a mission and you worked on it, and it was important for you to do your job” (2011). Messages of equality and solidarity like these were not present in many science museums and Science Museums, until recently, in the early 2000s, when a movement demanding both diversity and inclusion for all was implemented in many museums (Schwartz, 2005).

In the 21st century, the Science Museum that is the focus of this dissertation has made efforts to address these issues. During this time, it has continued to grow in both its research on astronomy and technology, which has also included its educational programming for underserved communities. This included the Science Museum’s outreach in Urban Area and beyond, focusing on not only improved exhibit design, but also programs that would better reach multiple audiences that might not even make it into the museum. Since 2007, according to Science Museum staff on the museum website (2016), the Science Museum has also been the host of a new visualization and research center, increased the amount of diversity on the staff, changed many exhibits to be inclusive of younger learners, and also participated more in crowd sourced research in the field, often known as ‘citizen science.’

The Science Museum expanded its presence online in the mid 2000s. This meant more information of the collections was available online, including that of Citizen Science, which took off as an online platform for participants to engage in through its launch in 2012. The Science Museum's online presence allows for audiences to engage with the Science Museum through technology, as many are interested in the topics they present but lack time and funds to visit the museum. By allowing visitors to visually engage and learn online from the Science Museum's programming, this museum is allowing itself to both innovate and participate in 21st century learning. Like most museums in the 21st century, Science Museum possesses a crafted statement in regards to diversity, including a mission statement that covers this in further detail. In the mission statement, The Science Museum states that it must engage audiences through discovery and empathy as well as to reach new individuals to teach and inspire learning. The Science Museum also included a diversity statement that includes the expansion of knowledge to all residents and non-residents of the Urban Area and beyond, as well as changing faces in staff and board members.

While many Science Museums are updating their exhibits and educational materials to bring the stories of marginalized contributors to their exhibits, such as the California Science Center, the Science Museum is also combating this issue of the lack of diversity through their programming. Indeed, diversity is arguably key to the outreach of the Science Museum, in addition to preservation and education. Additionally, and arguably, because of its location in a city known for its diversity among its population, a variety of different visitors can be seen coming through its doors, but also many different types of students who are coming to the Science Museum. Understanding how these students learn, as well as the social and historical issues that have faced the schools that they serve, is one way that the Science Museum is creating a more diverse and inclusive environment for participants.

In order to better understand engagement in museums, the role of equity as defined by Philip and Azevedo (2017) should be understood in this context. Of the three main points in this argument that these authors made in their article, one of them, the concept of ‘fairness’ in the face of ignoring issues of historic injustice, is an issue that has arguably faced all museums, especially science museums. This is because of many museums’ historic nature of ignoring injustices done in the name of science, choosing instead to focus on discovery and innovation done to further humanity, even if it means ignoring or erasing historical contribution or challenges. While some science museums have argued that social justice would detract from the discoveries made from previous explorers and founders within the sciences (Rader & Cain, 2014), it is part and parcel of museums now, in the cause of equity. One of these forms of increasing equity, is to recognize the previous forms of injustice, and expanding audiences for whom the museum serves. This is explored below with a specific focus on education, museums, and social justice.

Equity and Access in Science Museums

This history of ignoring injustice in the name of science throughout society lays the groundwork for the necessary means to address equity. This mode of power also was concurrently happening in the museum field, as it continued through most of the Industrial Revolution and the subsequent post-World War II era, where the wealthy and influential not only supplied the funds for museums as patrons, but also had a strong influence on the culture of whom the museum catered to. This included the conservationists and curators who preserved, selected, and provided interpretation for the pieces that were displayed in the museum (Suarez &

Tsutsui, 2004). These often came out of the interests of the wealthy themselves, sometimes for the benefit of understanding and learning more in depth about natural phenomena, such as the Mütter Museum's founding which stemmed from the need to supply the University of Pennsylvania's medical school with examples of diseases and unusual phenomenon within the human body (Worden, 2002). Mütter's interest in collecting and showcasing scientific finds and quirks was not unusual at this time, as many curator and collectors found themselves doing the same in many academic settings, which also included museums. This also included displaying scientific and engineering achievement by contemporary Western scientists, ranging from the plow to the mine, often leaving the achievements or contributions of non-Western individuals out of the museum narrative (Falk & Storksdieck, 2001).

These add to the issues facing museums to create and support opportunities to learn. These include the pedagogical (namely, can students who are not used to free-choice learning engage in learning opportunities in a museum?) and the practical (such as, how can under-resourced schools afford the costs of a field trip?). With that stated, museums can play a role for students who have the ability to come to their doors, with the expansion of the museum's outreach through programs. By drawing on their collections and resources of scientists working in museums, museum educators can also provide many of the tools, such as scientific specimens, for students in urban schools to engage in scientific inquiry and discovery. However, it is about getting the individual students to the doors of these places of learning that often causes the biggest issues when it comes to the ability of students to participate in the museum as a learning environment.

Museums, often due to their location within urban areas, serve a larger public population that can freely engage with learning outside of the classroom. By being in a large urban center, museums and their learning spaces within can become an educational environment that can bring together a much larger and diverse audience than a classroom could. This also provides museums with the opportunity to teach and engage with communities within urban centers, some of which have evolved in both exhibits and programming to reflect these communities, even within science museums (Seixas, 1993). As a result, museums and their learning environments within can serve diverse audiences by creating an inclusive learning environment that is free of classroom assessment and structure (Anderson et al., 2003). This inclusive environment is not, however, without its challenges. Often museums find that their general visitors, especially those who come to the museum on a repeat basis, are wealthy (Falk & Dierking, 2008). This stands in stark contrast to the majority of youth who live in urban centers (Watkins, 2001).

Issues from this area of traditional learning are also an opportunity for museums to assist in students' experiences, who can reach a much more diverse audience, including adults and non-English speakers (Monk, 2013). With that being stated, museums are bringing together communities to face challenging issues within urban centers (Dodd et al., 2010). Gutwill and Allen (2012) have argued that any group, whether composed of a school classroom on a trip or a family group, can successfully engage in learning in a museum. Other authors, such as Ash (2003), have suggested this, even stating that the closeness that a learning group has in their affiliated culture (be it classroom or family-oriented culture) will help learners engage with the material. By allowing learners to engage openly with their environment in which they are learning, inquiry and the open educational space will assist learners. Opportunities for museums in teaching include inclusion, inquiry, and information for a more diverse audience. The need for science is founded in the need for scientific literacy, a common part of public education that gained traction within the 20th century and the Cold War, and one that continues throughout the beginning of the 21st century as well.

Overall, diversity and inclusion are two topics that have been a part of education, including science education, for many years. How they are determined is through the idea of equity. This is one reason that museums and their subsequent programs are sometimes laureled as the true form of equity and access for science education, as these institutions are designed for a larger public that does not turn away visitors. However, this also follows into the issue of creating plans about access for science education, as well as equal opportunity, which, just as previously stated, still comes with the issues of proving useful to greater society, including bringing economic stability through career choices through access in education. This is discussed in the next section, in which museums, education, and social justice and the connection among all three are explored.

The Relationship between Museums, Education, and Social Justice

As mentioned earlier, one of the defining parts of an urban context is a large, diverse population. A large population with different ethnic, religious, and geographic origins provides an opportunity for participation for museums, who can reach more diverse audiences, including adults and speakers of multiple languages (Monk, 2013). Though museum patrons have historically been more upper-class, with more years of education (Falk, 2004), efforts such as free day and public museum passes have played a role in expanding the diversity of museum audiences during the 21st century, especially in cultural capital rich cities, such as Urban Area and Washington D.C. Subsequently, the inclusion of museums and communities are an opportunity in which informal education can reach a wider audience than the traditional school, allowing adults to learn alongside their children and community members.

Many museums have become, arguably, free-choice learning environments in which learners select and engage with the subject through reflection and self-guided inquiry (Jimenez Pazmino & Lyons, 2011). Additionally, many have focused on making their exhibits and experiences more inclusive to a diverse field of visitors (Gutwill & Allen, 2012). In addition, the general model of museums and science have evolved from places of historical and scientific collection, to a model of education that serves a much larger audience and public, and will continue to do so in an ever-evolving fashion (Anderson et al., 2003). However, common issues that face students in cities, such as the need for test preparation and administration needs in order to manage and assess the student population, stand in the way of museums being used for enrichment. As a result, although museums could greatly benefit urban schools in terms of increasing equity within science education through out of school learning experiences, there are many issues in the implementation of their use.

Science, however, raises a special concern. The American Association for the Advancement of Sciences released a statement in 2011 regarding this, as the United States lags behind many other nations in science performance in their elementary aged students. Although there are difficulties within the use of museums, there are also many benefits to the use of these institutions in order to increase the amount of learning opportunities gained for students. As mentioned previously, the lack of funding and time is not an uncommon barrier for many museum visitors and others that might benefit from these educational environments, the population of which includes many urban students who would otherwise benefit from the educational enrichment that a museum could provide. In fact, access and relevance is one of the greatest challenges that is often seen as a barrier to urban participants engaging in programming at many museums and other places of opportunities in the field of science education (Delpit, 1988). This extends to museum programming, which can have a positive impact in learning, especially in student performance in challenging subjects (Yoon et al, 2012). Though the argument may be that the population who attends a museum is more likely to seek out educational experiences during their time off, an inquiry-based activity still involves a positive experience for students who participate (Herron, 1971).

Informal learning is a unique opportunity for in-depth educational experience in museums, as they often allow the subjects that students are studying to come to life for learners. This is in addition to the fact that objects such as labs, computers, and materials have played a role in the transformation of American science curriculum. New findings in science are often discovered by scientists, many of whom work closely with museums for both funding and a source for both laboratories and collection spaces (Stevens & Hall, 1997). With this work from direct scientists, museums often display cutting edge or brand new developments in the sciences, allowing students to engage with their materials in innovative ways that could not generally be replicated within the classroom.

Challenging materials and subjects are now much easier to work with in difficult classroom learning operations thanks to more hands-on learning opportunities available for students (Gresalfi et al., 2008). These issues of fostering challenging materials are part of a history of inequality in science education, why it occurred, and how it can be addressed in terms of equity, which will be seen next.

A Brief History of Inequality within Science Education

Due to society being technologically far more advanced in the 21st century, that science and technology education is considered a true asset of every member of society (Apple, 1982). However, science education is still constrained by many of the inequality issues that plagued science education at its inception, ranging from the current issue of high prices of many science enrichment activities to the charter school system, which has used neoliberal policies of the free-market approach of pushing careers and educational paths deemed more financially prudent for economically disadvantaged youth.

Public/charter secondary schools, as well as the aforementioned land grant universities, are not the only way in which the population at large has been educated in American history. This initiative of supporting students in these subjects is also seen by the majority of the community colleges in more populated areas, with the highest number of these institutions being located in California, Texas, North Carolina, Illinois, and New York, which, coincidentally, are also the states with the highest number of populations, as quoted by the Digest of Education Statistics (2001). These institutions have offered a steeply discounted or free education to income-inefficient students who are interested in garnering an Associate's degree in the sciences (Kahlon et al., 2018). However, instead of emphasizing a journey onwards to a Bachelor's degree and perhaps graduate school, many of these programs instead focus on the completion of an Associate's degree so that their students can focus on a less educated role in the sciences, such as a medical coder or certified nursing assistant (Watson et al., 2018). While these roles are important, in our current society, they do not require the education or professional training as that of a more advanced professional, such as a software engineer or a surgeon.

While these positions are plentiful in the 21st century, and may even often some form of job security (a necessity in the wake of the 2008 Recession) they offer little career advancement and less intellectual stimulation than other positions that require heavier amounts of education and stronger skills that would be expected from a career in the STEM fields. It could even be stated that, in this case, there had been little to no advancement from the porters and clerks of the late 19th and early 20th century, and that students of a lower socioeconomic status are still faced with this issue of classism to this day (Watson et al., 2018). Some practitioners in these industries of technology and the applied sciences, such as engineering and medical science, argue that this simplistic form of education pushed upon students in these educational environments is a necessary form of training for a future population of workers, and that there is a need for assistants and a basic labor force in all fields, including science (Maltese & Tai, 2011). There is some truth in this statement, as with an aging population and a more diverse workforce that uses technology more for communication and transportation, having these types of positions with a strong workforce behind it is necessary for society to function (Grady, 2011). Grady also states that, by focusing these simple positions onto socioeconomically challenged students, educators and administrators are re-enforcing the stereotypes that these students are not deserving of a higher education or of a stronger standing in STEM fields as a result.

Though well meaning in its message, the idea that some students are expected to earn an Associate's degree despite talent and drive, is reminiscent of the argument between Booker T Washington and W.E.B. DuBois, whose arguments on practical or philosophical approach to educational opportunities are reflected in expectations of students to this day. Washington recognized the disparities of his contemporary society, and advocated for elevation in status through hard work, industrialization, and craftsmanship, whereas DuBois saw that this mindset would only keep themselves from advancing higher within the social world, and that only through a small group of intellectuals in their community, as well as the application of Civil Rights, would they advance further in society (McGill, 2005). Although this is an argument between two scholars from many years past, this is not very far removed from the debate of where today's pathways for STEM may lay for students who may not have sufficient access to educational and advancement opportunities, including additional engagement in the subjects outside of the classroom.

The role of race should also be acknowledged as a contributing factor to the inequality present in science education throughout the history of American classrooms. For many white students, science and math classes were emphasized and kept diverse in subject matter starting at the end of the Second World War (Apple, 1982). Rather than prepare a society knowledgeable in the classics and history as was previously championed by the ruling classes, this new order was to prepare students for either a university classroom in the sciences or technology, or as an alternative, a well-paid union position, such as that of transportation engineer or firefighter (Kliebard, 1999). These positions, to cite Bonnett (2017), were for privileged, white males in American society during the Cold War period. Conversely, African-American and Latinx students have often found themselves in classrooms that did not focus or supply the same format, and, even if they were enrolled in science classrooms, the application of taking university courses were often not applied to them. Instead these students were encouraged to go into the lower-paid positions in technology and engineering, such as manufacturing, factory assembly, or construction (Au, 2012).

At this time, many of the lesser equipped classrooms focused on repetitive learning, rather than a challenging and engaging classroom in science. Students, while also expected to participate in the sciences as professionals, were expected to participate in much less rigorous curriculum and subsequently, less visible roles that could eventually lead to higher roles in leadership, such as machinists or factory workers (Watkins, 2001). Thus, the idea of a 20th century scientifically literate citizen at the end of the 21st century, though important at all levels, still adhered to the racist and classist ideals of mid-century American political systems within public education. This goes back to the critical race issues arisen in the previous sub-chapter, in which the theory that students of disenfranchised backgrounds will not receive the same quality of education, even if theories have proven that these designs have worked in other schools or learning environments. This issue of the dividing of different schools have multiple issues at hand, including how science classrooms and subsequent learning within them are constructed, and expectations of students are thus changed.

Part of the issues within these divides of schooling involved the supply and design of the science classrooms themselves. Having a well-supplied classroom for students who either displayed their talents or could afford the best education was not the only affordance that they were offered as learners within the science (Nguyen, 2017). There were also the different learning methods to efficiently produce scientifically literate citizens, a crucial role of the sciences that still echoes in many American classrooms today (Anyon, 1997). Being able to engage students in challenging modes of learning required more training and aptitude among teachers, who then were drawn to institutions who would generally afford these applications of teaching scientific literacy. One of these methods was the application of inquiry, which will be described below.

Although students are encouraged to finish their degrees, within our current neoliberal society focused on the usefulness of a degree rather than the quality, many have been found to select educational opportunities in the sciences that do not require more engagement in the subject outside of the classroom, often rendering them as practitioners, but not experts in their field (Edelson, 2011). As a result of this need, there are arguably many modes of learning that make more challenging and rewarding parts of science careers accessible for young people, such as using the amenities of the cultural capital available within the city and hands-on learning. This is also true for students who are socioeconomically challenged, or may lack access due to their location or race.

Racism, as well as both sexism and classism, has had an unfortunate relationship with science education for many years. As the abilities of students in subjects have been called to question by government and school administrators at both local and national government, who performs well and who does not often inhibits future prospects and interest as a result. If a student has a negative experience with a subject in their mandatory K-12 education, they often will not seek it out as an adult (Emdin, 2007). While this might strike as a common issue through all subjects, (conjuring the image of the child who hated English turning into the adult who hates reading novels, for example), this is especially damaging to the sciences, which often relies on public and government support in order to continue the work that scientists and other STEM professionals do. As a result, the ability to not only understand, but to be represented accurately and fairly in the sciences is an issue that has been present for arguably the last century in science education.

Science had been taught in American education for many years, starting in the 1870s, after the spread of public education in the early 20th century and the mandatory attendance of children in public education (Kliebard, 2001). This differed from the original content taught in many classrooms, which originally focused on writing and arithmetic, the two subjects most

Americans needed in order to function in a society that did not generally require in depth subject knowledge. In historical American classrooms during the 19th century into the early 20th century, education changed from a single room in a one room schoolhouse, to developing into a multitude of classrooms and subjects that engaged students in different methods of learning that correlated with principles that reflected the greater needs of society (Apple, 1979).

Even though many educational institutions flourished in the post-war period, especially universities, who saw enrollments skyrocket after the conclusion of the second World War due to the implementation of the GI Bill (Kliebard, 2001), not all members of society benefited from this expansion of education. Instead, the training of a new workforce was the focus of education that the latest American generation would receive, especially with new amounts of science and technology that were expanding in the international stage after the dropping of the atomic bomb on the cities of Hiroshima and Nagasaki in 1945 (Spring, 1974). This was the result of not only the development of the bombs, but also the beginning of the Cold War that required more scientists and engineers to harness the types of power arguably needed for the American government to succeed in this silent but deadly conflict.

As stated by Kliebard (2001) in his background on the history of the American curriculum, although science itself would be available and expected for American students as a subject, the types of science education would be divided by both the geographic and socio-economic status of the students during the period after World War II, which occurred from 1945 through the fall of the Soviet Union at the end of the 1980s. These geographic issues were often found on the boundaries of different school districts, as well as the needs of the communities within who were sending their children to these schools to be educated. For many of these communities, the focus was on making sure that their children could adequately compete in a workforce that required skills to both be economically successful and to potentially compete with challengers to America's role as a superpower after the rise of the Soviet Union and the subsequent Cold War.

This lead to the Cold War and the resulting Space Race with the Soviet Union, which led to the expanded need for scientists and engineers in the United States (Kelly et al., 1993), but equity within this was higher education for some, while merely training for others, leading the idea of keeping non-white, non-male individuals from obtaining positions of power and prestige, even if they were still working towards a common goal of keeping the United States of America ahead of the rest of the world during the Space Race and Cold War. This was not just an evolution of typical American society from rural to urban, as there are still rural areas today, though the largest percentage lay within urban centers. This need for producers of quality materials was also seen through the development of large-scale weapons and communication systems after the second World War. This resulting call to arms of the science and engineering world was thus placed in the hands of the educational system in order to produce workers capable of engaging with new technologies that would allow them to compete at the international level. This call for production of more professionals in this realm resulted in the expansion of science classrooms within public schools in the US, as well as the role of the lab in the school system, even in such diverse learning environments as an arts class (Halverson, 2013). Progressivism in this role is defined as a period of social upheaval and focus on economic disparity and social justice in between the years of 1880-1920 (Buenker, 2002).

DeBoer (2000) argues that the call for more scientifically literate citizens also came out of the demand by many contemporary scientists themselves during the post war period. By this date in the timeline of American schooling, the humanities had been firmly in place as part of a rigorous educational program for students, where the top students were expected to be masters of the great books and possess a strong knowledge of classical studies (Kliebard, 1999). Science, arguably, needed to have the same rigor and muscle that had been given to subjects such as history and reading. As a result, by the wealthy and powerful of the nation emphasizing science as a subject that was necessary for a citizen to participate in a developing and changing world, the subject was given more breadth and importance in the American classroom (DeBoer, 2000). In order to create scientifically literate citizens for the Space Age and subsequent Cold War, science had to become more of a staple subject in American education.

This goes in part of Philip and Azevedo's understanding of equity within science education in terms of access, as it pulls in their concept of increasing equity in order to keep the status quo of society in order. For white, wealthy students in American society, the concept of equity within science education was to put them in order to obtain high paying, high profile positions in the sciences, relegating non-white, non-male members to lesser educated, less seen jobs in this era of technological advancement, thus keeping the societal status quo. This meant that the upper echelon of Cold War society were not only visually responsible for the discovery of new technologies and sciences, but could claim the discovery as their own, due to having the education and prestige needed to do so.

This issue within equity was also mentioned within Dawson's (2014) framework of understanding. According to Dawson, individuals who are not exposed to different forms of sciences through educational opportunities are less likely to engage within the sciences as a result. This includes through hobbies, formal education, and other forms of learning that encourage inquiry and other methods of scientific thought and process. It also encourages the participant to engage further, once they have mastered this subject. However, with the ability to engage in this subject lacking, as many did during this time period, equity was not able to be obtained, even at the layperson's level.

Science, like many of the educational topics that were covered before the Industrial Revolution, such as reading and math, focused on routine memorization, such as memorizing the taxonomy of distinct species of animals. This would be classified into a Westernized, Eurocentric format using Greek and Latin names for new species, thus using the classics that were held to such a high importance during this period between the Enlightenment and the Industrial Revolution to the effect that the foundation of many liberal arts educations were founded through this school of thought (Au, 2012). However, memorization of facts did not allow for anyone who did not possess the ability to receive a higher education to be trained in the sciences including men of color and all women.

It should be acknowledged at this point that many of the scientific advances that occurred before the advent of the 20th century was often by wealthy hobbyists, and even non-scientifically trained laypersons (a common, somewhat apocryphal, example being that of Benjamin Franklin, who was self taught in his discoveries). The idea of the 'everyman' learned in different forms of knowledge that would be practical in a world that began focusing on industry, became a focus in many Western countries (Reeder, 1980). This was especially prevalent after the two World Wars in the first half of the 20th century, where there was an increased call for professionals knowledgeable in engineering, communications, and other forms of scientific industry that could arguably be used in a militaristic or other form of neoliberal work (Spring, 1974).

The need by the Cold War administration of the United States government, led by consecutive presidents Dwight D. Eisenhower and John F. Kennedy, to create a technologically advanced working population meant that the United States would not only continue to be a superpower, but could both arguably bypass the Soviet Union and continue to lead the world as it had after the fall of the Axis Powers after World War II. This concept of global power and industry within the Cold War permeated into all facets of society in the American landscape, including the science museum, as mentioned by Rader in Cain (2014) in their analysis of the design of museums during this time.

Equity in Science and STEM Education

STEM subjects (Science, Technology, Engineering, and Math) have been linked to higher salaries and better job security. However, due to the multiple power structures in society, some disenfranchised groups have not reached similar expertise at the same rate. These issues have been recorded in different formats throughout educational research, starting with the beginning of STEM education increase during the 1950s and 60s in American education. This is continued through the modern day, with different modes of learning within STEM facing issues of equity.

Research has shown that disenfranchisement has had roots in multiple facets of society. Suter and Camilli (2019) have shown that research on science and math education in the United States has been conducted since the 1960s, where concerns about other countries outpacing student ability in these subjects were realized. Moreno (2019) makes the argument that both inside and out of school education in these subjects are crucial in developing comprehensive thinking skills, along with other abilities such as understanding processes and communications. This is supported by the claims that more innovative opportunities and structures for teaching and learning in these subjects should be applied by educators in order to work towards equity among the students who engage in these subjects (Morganson et al., 2015). However, as Beilock et al. (2010) have noted, these subjects are not just limited in terms of equity to the students that are learning, but also to the educators who are teaching them.

The issue of equity among both student and teacher has been documented, but how it is interpreted conceptually among learning scientists and other researchers has differed. Killewald and Xie (2013) argue that one of the primary reasons that students who identify as African-American or Latinx do not seek higher education degrees in the sciences is due to the lack of models, as opposed to white or Asian populations who have many examples in the academic science fields. People in these positions, such as scientists with advanced degrees, contribute to society through research and/or through teaching, but there are far fewer people of color in these positions (Carlone & Johnson, 2007). Without mentorship and models for disenfranchised youth, there is a distinct disadvantage in terms of opportunities, such as the ability to become a professional with an advanced degree (Grant & Ghee, 2015). As a result, many younger students, even if they perform well in the sciences in school, often choose different fields in which they feel they are more represented (Bynum, 2015).

Underrepresentation in the sciences is not the only challenge minoritized students face as they consider careers in the sciences. Supplying resources to support science education in schools, which includes inviting students and teachers into museum spaces during field trips is a powerful tool for students to learn about different subjects in the sciences, and one that is encouraged by researchers (Killewald & Xie, 2013). However, financial resources to support science learning have been inequitably distributed such that students of color and students living in poverty do not have access to these opportunities (Kahler, 2015). Funding transportation and managing other logistics can be challenging for under-resourced schools. Field trips to museums require bussing and time away from the classroom, and other administrative issues, such as distributing and receiving in return permission slips from busy parents (Evans et al., 1970). In addition to financial challenges, students' perceptions of scientists and their perceptions of their own identities play a role in how students engage with the sciences in and out of school.

Diversity in the sciences professionally begins when students are learning and engaging with the subject as children. Issues ranging from language in the learning environment to classroom behavior and attitudes towards the subjects play a massive role in how students perceive themselves and their own interactions with the subjects after they finish their mandatory K-12 education (Evans et al., 1970). This issue has been explored for many decades, and attempts to change this course of the sciences has ranged from scholarships to multi-language programs to teacher preparation in inquiry-based learning (Pomeroy, 1999). Raudenbush (2005) has identified the issue of a lack of diversity and the American Association for the Advancement of Science devoted multiple issues to the subject as well (AAAS, 1993). Museums, especially in the sciences, have the opportunity to address these issues through both their work in radical inclusion.

The Question of Discourses of Equity within Science and Museums

Philip and Azevedo (2017) explain the discourses of equity that are present in science education in contexts of out-of-school learning. Perhaps most importantly, they write that the goalposts of learning and access are constantly moving. The shifting of need for adequate science education is based not in the idea of creating a literate society that is interested and engaged in learning for learning's sake, but in order to create a more competitive workforce for the United States in an increasingly global economy. This Industrial Revolution ideal is found still in the Internet Age, where science (and STEM) education and its push for diversity is to increase the talent pool of the American economy. Therefore, access and equity within science programming at museums may find itself not necessarily with the social justice mindset that many might associate modern education movements with, but rather previous modes of access if the greater economy of the country may benefit from this endowment of equity for students.

Benefitting society through economic expansion is not the only issue at hand with equity and access within science education outside of the classroom. Dawson's (2014) piece in regards to equity within informal science education also explains this issue at hand, with a focus on social inclusion of different audiences in the sciences. Laying out the various forms of access, issues such as previous knowledge and interest in a subject are raised in terms of enjoyment and, most importantly, the ability to retain the knowledge that they acquired while engaging with the educational experiences. Other issues, such as literacy and social access, are also mentioned as issues within the framework of access for participation within informal science education in Dawson's work. If the population can physically access the informal science education, but not be able to understand or enjoy the information on display, they will not participate or seek it out again.

This draws back to other arguments scholars have made in terms of access for quality science education, in which the many different forms of issues with equity are discussed. Whether it is affiliated with culture (Ash, 2003), socio-economic background (Au, 2009), or location (Kliebard, 1999), making sure that science education is accessible to the public in an easily understood format is not easy, especially when administrators at a higher level within the institution argue that this footprint of education must be seen in a way that greatly benefits society--through economic means, such as careers for students who partake in programs provided by schools and other places of learning within society. Even though other issues, such as student performance and change of need from society also play into the challenges of quality content in science education, understanding equity and access for education within the sciences is crucial in understanding why and how places of access, such as Science Museums and other science museums, must interpret and subsequently distribute programs for the public.

Why Is This Relevant?

Maurice Swinney, the Chief Equity Officer for Urban Area Public Schools, said during a meeting of an Urban Area learning network on February 21st, 2019, "Equity means providing all students with opportunities and resources to meet their different needs and aspirations, and celebrating and embracing the individual cultures, talents, abilities, languages, and interests of each student." He continued during this talk, "Equity requires preparing all students for global, social, and economic opportunities in the 21st century" (M. Swinney, personal communication, February 21st, 2019). This definition of equity is one way of understanding the very important work Swinney and so many others are trying to do in their work in and out of schools in the US. But it is not the only definition, and it may also not be the way that the teachers who work for Swinney in CPS or the principals think about what it means to support equity in science teaching and learning. By understanding how equity is understood by those who work to establish equity in schools and in other learning contexts for young people can change how practitioners go about this work and how administrators, policy makers, and researchers can better support it. Seeing how science as a form of equity has been engaged through education, both within the formal and informal, is especially important in science, as it has the potential to not only increase inquiry, but also increase participation in STEM careers once a student has left the program.

It may seem intuitive that the traditional science classroom is where the majority of science education takes place. However, over the average person's lifetime, the most that they learn about science is in informal environments (Falk & Dierking, 2008). This, as well as the additional work researchers have completed to show that effective knowledge of science and other STEM subjects is responsible for both attitudes and voting behavior, museums have a greater role than ever to produce experiences that produce knowledgeable individuals who are willing to promote and protect STEM research and careers for the American people (Nisbet & Markowitz, 2016). A fundamental concern among scholars within STEM education is how educational institutions can ensure that all students become scientifically literate to prepare them in their everyday lives as citizens and, in addition, how school science can ensure that enough students are able to pursue careers in STEM areas once they leave their institution as graduates (Fensham, 1985). This is a crucial outlet for increasing all people's access to STEM education.

The idea that museums and their experiences are a collective space for all of the public to be educated in is part of a newer evolution that has been seen at the late 20th century and has continued on through the early 2000s. This is because museums have evolved to include not only their traditional space, but use their collections and staff to further enrich the public. Museums are suited to provide quality experiences with authentic parts of their collections and getting both curiosity and interest from the interaction with these materials with the public (Witcomb, 2003). Because of this collective understanding that needed to be met, I conducted a study at the Science Museum in order to explore how educators talked about and thought about equity in a program designed to increase the Science Museum's outreach. Below are the methods I used to collect and analyze data in order to consider the question of how educators talked about equity in this program.

Chapter III: Methods

Overview

In this chapter, I begin by describing my position as a researcher, from how I came to the Science Museum to the work that I conducted while positioned there. Next, I will explain both my data sources and methods of data collection in order to answer my research question. Finally, I conclude with describing methods of data analysis.

Researcher Position

This study was conducted as part of my role as an evaluator at Science Museum. Because I was also a doctoral student at the time I was working at the Science Museum, I received permission from the Science Museum and from my doctoral advisor at the time to conduct this study both in my work capacity and as my dissertation. As an evaluator at Science Museum, I had no participation in curriculum design, but the open-choice, inquiry-based framework for the curriculum appealed to me as a researcher and an educator, and I was eager to study this kind of curriculum. As a graduate student, first in the Learning Sciences program and then in the Curriculum Studies program at the University of Illinois at Urban Area (UIC), my research has explored learning in museums, with a specific focus on museums in urban settings. I began my doctoral studies at the UIC Learning Sciences Research Institute, but I transferred to the UIC College of Education after one year because it was a better fit for my research trajectory.

While I was a doctoral student, I was approached by a future colleague at the Science Museum about museum evaluation, and by the end of the week, I had secured a contract as an evaluator for the Science Museum for their project with a local high school. I was responsible for conducting interviews with students and faculty, which also included investigating students' school test scores for three years. These scores specifically looked at the performance of students in STEM subjects. As an evaluator, I was asked to consider how the Science Museum's programs affected participants' school performance. Around this time, my advisor at the time, Pamela Quiroz, suggested that I look into Science Museum as a potential site for my dissertation research, and to see if it was possible for me to use the gathered data for my dissertation.

After completing this evaluation, Science Museum asked me to stay on to evaluate an upcoming program that would span the entire school year and focus on students from multiple schools throughout Urban Area public school systems, rather than just the one selective-enrollment school that participated in the first program. Because the Science Museum staff thought the selective high school's three-year collaboration with the Science Museum was a successful program, a more expansive leadership model was suggested by Science Museum administrators. Science Museum secured external funding to pursue this more expansive leadership model for students in under-resourced areas throughout Urban Area. Students who participated in the leadership program would receive a stipend for their work and research at the Science Museum. Different from the first program, the membership in this program would include students from all over Urban Area, rather than just one high school in Urban Area. Because of my interest in studying museum programs in urban contexts, this seemed like an ideal dissertation study.

For Science Museum, their expectations of me were simple: they needed a visiting researcher to evaluate their program to see if it was worthy of expansion into future programming. For myself, I saw this as an opportunity to also collect data for my dissertation on informal STEM teaching and learning.

Although I collaboratively designed the survey questions that were part of the evaluation, I created the interview protocol for my dissertation data. My role as an evaluator of the Science

Leadership Program at Science Museum was to evaluate the program's outcomes, which I used as a concurrent opportunity to collect data for my dissertation. However, for my dissertation, I was conducting a parallel study that investigated discourses of equity. I pursued this parallel study because I was interested in the ways that this same group of educators and students participating in the Science Leadership Program at Science Museum talked about equity in their work. These two pathways of research, though conducted at the same time and with the same source, are different. They were simultaneously conducted, with one serving as evaluative practice and the other serving as an exploration of discourses of equity.

Setting

Development of the Science Leadership Program

The Science Leadership Program was an expansion of the Science Museum's previous three-year partnership (from 2011-2014) with a large Urban Area high school. To differentiate the Science Leadership Program from its predecessor, I will refer to the previous program as 'Select Enrollment School' or 'SES' and the program as the 'SES/Science Museum program,' as it was a partnership designed to work closely with this one school. According to the self-reporting of students and educators at this school during this initial program, students who participated in the SES/Science Museum program showed improvement in their science learning during the three-year partnership with Science Museum, which is why the Science Museum wanted to expand the program.

Students participating in the SES/Science Museum program worked at the Science Museum as guides during the school year. Their work ranged from acting as docents to giving introductions to Museum performances. In addition to their work at the museum, participants in the program were also taking part in designing and trying out scientific investigations at their high school with the guidance of a Science Museum educator on air balloons and other STEM research areas. As part of the SES/Science Museum program, The Science Museum educators also supported other enrichment activities for students, which included taking field trips to both the Science Museum and to conduct scientific experiments in various parts of Urban Area. This all culminated in a balloon launch in the spring, where students' research on weather balloons was put into action as they tested out their designs and experiments during Operation Space Launch with Science Museum.

The perceived success of the SES/Science Museum program helped launch the Science Leadership Program. The Science Museum leadership believed the expansion to include students from across the city was an evolution of the program that would provide more equitable access to the Science Museum program for young people across the city. Science Museum's directors believed that the program could be repeated with a more diverse group of students from different public schools across the city. In the Science Leadership Program that I studied for this dissertation, twelve students engaged in leadership and science activities throughout the Urban Area during the 2014-2015 school year.

Organization of the Science Leadership Program

The students who participated in the Science Leadership Program were nominated by educators and administrators at their schools. This program was imagined and supported by both Science Museum and School Supporting Nonprofit. School Supporting Nonprofit (SSN) is a non-profit organization devoted to after-school programming for Urban Area young people. The Science Leadership Program curriculum was designed by Science Museum educators.

Students, organized in groups of 2-3 per group, met at different locations that included a West Side neighborhood; a Near North neighborhood; a South Side neighborhood; and a Far South Side neighborhood of Urban Area. Meeting locations in these neighborhoods included schools and community centers. One group of students met at the Science Museum itself. The sites were selected to be close to the students' homes and/or schools. This is because students lacked adequate access to routinely participate at the Science Museum, and a goal of this program was to increase access and equitable opportunities for students across the city to participate in Science Museum programming. Lack of transportation is a routine challenge for students who want to participate in elective enrichment activities, as opportunities to engage with experienced professionals and with other aspects of enrichment activities often require time and/or travel (Resnick & Rusk, 1996).

During the Science Leadership Program, students met weekly after school in their small groups at their satellite sites to conduct experiments related to the physics of flight and other subjects in engineering and science. Each satellite site focused on different aspects of physics and movement, ranging from worms in space to the movement of wheels on boards in different physical environments. All student participants were given the choice of designing their own experiments under the guide of the educators that led them. Each group of students was tasked with creating a project that could eventually be used with the equipment that Science Museum had sent them, which would be presented after it had been used as part of the program's culminating event. This inquiry-based curriculum was designed by educators who worked with the students.

At each of the satellite sites, the students worked closely with mentors to develop STEM projects and design experiments that would finish with each of the experiments being lifted into the higher reaches of Earth's atmosphere. Educators from the various satellite sites did not meet with each other nor plan with each other. Rather than receive planned out curriculum, educators were given almost full autonomy in designing their curriculum and activities, with educators checking in with Science Museum staff to make sure they had received equipment the youth needed in order to conduct their experiments and design their projects. By having this type of relationship, the mission of the museum could be carried out through inquiry-based learning and access to Science Museum resources for youth who could not regularly travel to the physical space of the museum.

All of these projects were designed for the students to have them individually compete in Operation Space Launch, a competition hosted by Science Museum in April 2015 in which students would attach their science projects to weather balloons, and measure the distance in which they were lifted off, stayed above in the air, and when they fell to the ground. Although separated into groups that met at the satellite sites for most of the program, students did come together for a few meet ups at Science Museum, to check in with Science Museum staff on-site, meet other students in the program, and check in on the progress of the program.

One educator at the time at Science Museum, described the program's concluding event as based on a Science Museum's citizen-science program to develop high-altitude balloon and nano-satellite experiments using publicly available materials. At this event, all of the students and mentors gathered together to launch the experiments they had developed in their satellite sites. Because the students were preparing during the year for this culminating event, each group at each satellite site had spent the year designing a payload to be attached to a weather balloon. The payload had to be a scientific experiment that could record data while attached to a weather balloon from the Science Museum, but each group of students at each satellite site designed their own experiment within these parameters, under the guide of the educators at each participating site. Below I will describe in more detail how the Science Museum and SSN identified students to recruit to the Science Leadership Program. I will also describe each of the students and mentors who participated in the Science Leadership Program.

Participants

Students

The participants in this study included the students who were participating in the Science Leadership Program in the 2014-15 school year and their educators. Students who had engaged with prior School Supporting Nonprofit programs through Science Museum were approached by School Supporting Nonprofit staff members at the end of the 2013-14 school year, drawing on verbal information from educators as well as digital communication via messaging from students. School Supporting Nonprofit staff chose students to approach for this new Science Museum-based program based on students' enthusiasm and interest in the subjects that the program focused on. School Supporting Nonprofit staff and Science Museum educators also wanted to reach students who lived in areas in the city that were especially hard to reach in terms of equitable access to Science Museum programming. These selected students were then asked if they were interested in enrolling in a program (the Science Leadership Program) that would constitute more leadership opportunities and research experience. Thirteen of these invited students chose to participate in the new Science Leadership Program, beginning in the summer of 2014. One student did not attend the program, leaving twelve participants. One student came late to the first summer session and subsequently did not take part in the initial survey given to all participants, thus I collected 11 initial surveys.

Of the student population that presented themselves at the beginning of the program that took part in initial surveys, six identified themselves as ‘female’ (55%), while the other five reported themselves as ‘male’ (45%). Other categories of identification included ethnic background and geographic location in the city. 75% identified as African-American, 8% Bi-Racial, and 16% Hispanic. On the survey, students’ choices for their geographic location were listed in a format to keep identification of students safe, instead of labeling actual neighborhoods in which they currently resided. All students self-identified as upperclassmen in high schools across Urban Area, with two juniors and nine seniors. Table 1 below is a summary of the students who participated in the program with Science Museum and their self-identified gender and ethnicity (within the choices given them on the survey). They are organized in order of geographic location in the city:

Table I

<u>List of Students</u>

Pseudonym	**Gender**	**Ethnicity**	**Grade**	**Location in City**	**Previously worked with The Science Museum?**
Robert	Male	African American	Senior	East Suburbs	Yes
Miles	Male	African American	Senior	East Suburbs	No
Ken	Male	Hispanic	Senior	West Side	No
Richard	Male	Hispanic	Senior	West Side	No
Lyle	Male	Bi-Racial	Junior	South Side	No
Marie	Female	African American	Senior	South Side	No
Anna	Female	African American	Senior	South Side	No

Leslie	Female	African American	Senior	South Side	No
Liz	Female	African American	Senior	South Side	No
Abby	Female	African American	Senior	South Side	Yes
Emma	Female	African American	Junior	South Side	No
*Rachel	Female	African American	Senior	South Side	No

*This participant did not finish the year.

Educators

The Science Leadership Program included multiple educators, of which six were interviewed for this research. Four educators worked routinely with students at the satellite sites, and two educators worked full-time for Science Museum and supported the four site-based educators. The four site-based educators were chosen because they worked as science educators in the neighborhoods the Science Museum was trying to reach with this program. One of the issues that I mentioned previously for students to participate in museums was the length of travel time and distance to museums, which the Science Museum helped circumvent by having students participate at community centers and university sites closer to their home locations. There were two additional educators from the Science Museum who had helped design the program, assisted on different sites throughout the duration of the program, and coordinated the final program. Because of the depth of interaction with the students, I also interviewed these educators to gain a better insight into the program. The four site-based educators who worked most closely with youth at the satellite sites were not employed by Science Museum, while the two museum-based support educators were. I interviewed all six educators at the conclusion of the Science Leadership Program.

Each of the four site-based educators had the role of leading and guiding the students throughout their time in the Science Museum program. Students were responsible for directing their own projects leading towards the culminating Operation Space Launch field trip in a location outside of Urban Area. As a result, the role of the educators was to serve as mentors and guides to the students, rather than instructors, thus changing the traditional relationship between the teacher and student to more closely resemble that of a mentor and mentee relationship.

The educators who were selected to participate in the program had previously worked with the organization that supported this program at Science Museum. Because of the way that this organization identified and hired the four site-based educators, all had different educational backgrounds, sets of experiential goals, and expectations of individualized learning in the program. Each of the site-based educators had a different scientific disciplinary expertise, and their knowledge base and areas of expertise obviously affected the ways that they supported and guided the different students they worked with. Because of their different areas of expertise, the four site-based educators supported different kinds of designs for students' Science Leadership Program final projects. All of the site-based educators worked closely with their program students in supporting their preparations to compete in Operation Space Launch.

Of the four site-based educators, their differing areas of expertise led to the completion of student projects with the following four areas of focus: one educator helped students design an experiment that focused on applying physics from skateboarding. Another educator used their biology background to help determine how different organisms would survive in orbit using the most rudimentary protection from radiation. A third focused on plant material in orbit, and a fourth used her background in aviation to help students design and engineer a smoother rocket that did not require as much gas fuel. In addition to the four site-based educators, the two Science Museum-based educators, who had each worked at the Science Museum for many years, served less as hands-on instructors, and more as supervisors throughout the program.

Table II describes the educators who participated in Science Leadership Program. Like the students, they self-identified in terms of ethnicity, location, subject, and educational background within choices available to them on the initial survey.

Table II

List of Interviewed Instructors

Pseudonym	**Location of Educator**	**Race/Ethnicity**	**Subject Taught**	**Educational Background**
Ralph	West Side	White	Biology	Graduate degree
Sherry	Far South Side	African American	Physics/Engineering	Undergraduate degree
Ann	South Side	African American	Biology/Engineering	Undergraduate degree
John	Near North Side	Hispanic non-white	Engineering	High School
Lee	Science Museum	White	Physics/Engineering	Graduate degree
Mary	Science Museum	White	Physics/Engineering	Undergraduate degree

Location

- As mentioned in the literature review, although many museums are centrally located within cities, next to (arguably) accessible public transportation, they are not as often traveled to regularly by youth at the time of this study design in

2014. One of the goals of this program, like many others offered by the Science Museum (such as a family program where stargazing sites are opened throughout Urban Area, free of charge), is to encourage youth participation in STEM programming throughout the city. This allowed students to stay close to their schools and neighborhoods. It also allowed the program to be run by local educators, many of whom had previous experience with the Science Museum and all of whom had previous experience with science and/or engineering. Students at all satellite sites met on a regular basis, and focused on the final project, including some side projects, such as skateboards at the near-north location. Students were also paid a small stipend for participating regularly in the program, which is standard for SSN-managed programs. Materials were provided by Science Museum, ranging from robotics parts and kits to laptop computers, in order for students to work on their projects without being concerned about supplies.

The first location was at a university in a neighborhood on Urban Area's South Side. The second location was at a high school in a near-north side neighborhood. The third satellite location was on the far South Side, in a community center, right by the school that the participants attended (this educator was not included as part of the study). The fourth satellite location was in a community center in East Suburbs. The fifth satellite location was in a community center in a neighborhood on Urban Area's West Side, right by the school the students attended.

Study Design

This study is an exploration of the ways educators talked about a primary goal of the Science Leadership Program: equity. In order to explore discourses of equity (i.e., the ways that educators talked about equity with regard to this particular program at Science Museum and to their idea that young people have equitable access to science learning and engagement), I interviewed each of the educators. As noted previously, there were two parallel studies taking place during my data collection: 1) I was conducting an evaluation study of the Science Leadership Program for the Science Museum as a contracted employee; 2) I was conducting my dissertation research as an exploration into educators' discourses of equity while they participated in the Science Leadership Program. For the purposes of this dissertation study, I focus only on the exploration of discourses of equity, and I analyzed the interviews for this purpose.

I conducted interviews with all six Science Leadership Program educators. I then explored these educators' understanding and conceptualization of equity and equitable access to science teaching and learning through the ways they talked about equity in these interviews. Although I wanted to interview students, due to issues with the IRB process, I did not have permission to interview students. However, I was able to access and analyze open-ended essays students wrote as part of the Science Leadership Program. These essays were completed at the end of the program, and students reflected on their experiences in the program and what they had learned. In the following section, I describe in further detail each of the methods of data collection and data sources.

Data Sources, Data Collection, and Data Analysis

In this section, I will explain both the methods of data collection and the sources of data. I have identified a research question, which focused on discourses of equity in informal science education: In a museum outreach program intended to support equitable science learning, how did program designers, educators, and youth participants conceptualize equity in their discourse? Below, for this question, I will identify the data sources I have collected and the methods used to collect this data. The data I collected to answer my research question included interviews and student artifacts. Below, I describe a rationale for both of these data sources. Then, I list the question, I identify the data sources and methods of data collection connected specifically to the research question.

Interviews

The main source of data for this research was interviews with the educators who participated in the program. While interviews with educators included questions that aligned with my professional responsibilities to evaluate the program, interview questions and responses also supported my exploration of educators' understanding of equity (see Appendix B for interview protocol). These interviews were collected in March and April 2015 near the conclusion of the program. The interviews lasted for about an hour each. I audio recorded these interviews, took notes during them, and created transcripts of the audio.

With these interviews, I sought to understand how educators conceptualized equity as they talked about their participation in the program. Although the interviews were conducted only with educators, I also asked about students' experiences. The questions were open-ended. By conducting interviews with educators in the program, I also wanted to explore the influence of both personal background and education on the educators' discussions of students' experiences.

Below, and in Table III, I describe data analysis.

Table III

How did educators talk about equity, and how did I categorize their talk?

Discourse 1	**Discourse 2**	**Discourse 3**	**Discourse 4**	**Discourse 5**
Bridging in-school and out-of-school (from Philip & Azevedo, p. 528)	Community Acceptance (from Dawson, pp. 231-234)	Infrastructure Access (from Dawson, pp. 216-222)	Motivation/enjoyment, positive affective responses (from P&A, p. 529)	Increase access for a select few (from P&A, p. 528-529)

Analysis

I am adapting discourse analytic methods to explore educators' conceptions of equity based on how they talked about it in their interviews. According to Gee, "Discourse analysis considers how language, both spoken and written, enacts social and cultural perspectives and identities" (2011). Discourse analysis is well suited for classroom and educational research (Florio-Ruane & Morill, 2011). This is because the complicated interactions involved in a social setting, such as an educational context or a conversation between learners and educators, can be unpacked and explored using discourse analysis.

To analyze discourse, I first created a priori categories, drawing from Philip and Azevedo (2017) and Dawson (2014). I then read through the transcripts of each of the interviews, looking for language that I understood to fit within a particular category. Gee describes how language connects to actions and identities: "In language, there are important connections among saying (informing), doing (action), and being (identity)" (Gee, 2011, p. 2), and this method helped me to work from educators' language to argue their particular conceptions of equity. As I analyzed the discourse in this way, I better understood how educators conceptualized equity and framed their own identities, especially as educators talked about students' access to the program and to science learning in the program, how educators spoke about both students' experiences and their own in the program, and their own backgrounds and feelings towards places like Science Museum.

Below, I name each of the five discourse categories identified in the table above and that I used to analyze language in the interviews. For each of the categories, I include sample language from the interviews in order to show how I interpreted language as fitting within particular categories.

Discourse 1: Bridging in-school and out-of-school. In this example of Discourse 1 ("Bridging in-school and out-of-school") Ann is talking about how she viewed expansion to include more students in the program. "Do we have junior high? Leading towards creating STEM flair in the eyes of the younger students, so when they get there they're ready" (Interview, 3/11/2015). Words and phrases such as 'creating STEM flair' and 'when they get there they're ready' are two examples in which Ann discusses the concept of bridging in-school and out-of-school. Ann is saying that if their students did out-of-school science learning, they would subsequently do better in school (i.e., "when [our students] get [to high school] they're ready"). Ann is also describing access to a "culture of power," meaning that access to learning outside of school is not about student enjoyment but rather because this links to how a student can do well in school and subsequently lead to success in Westernized society.

Discourse 2: Community acceptance. Discourse 2 (“Community Acceptance”) was taken from Dawson’s (2014) framework. I understood this category as the “extent to which practitioners are willing to critically reflect on and redevelop infrastructure and resources to accommodate more people” (p. 231). As an example of the language that I coded as fitting within this category, Ann talked about involving more professionals from The Science Museum in the programming in satellite sites: “Maybe like, some scientists or leaders from the Science Museum could come out to the (satellite site), you know only a couple of times during the summer, you know, this was only a couple of times during the summer, and you know, then the students could have the opportunity to visit the Science Museum, and then the day trip, and then go and launch the balloon” (Interview, 3/11/2015). I coded language as fitting within this category when educators spoke about the different resources from the museum (including people) that could be brought to their communities. I interpreted words and phrases such as ‘scientists,’ ‘come out,’ and ‘opportunity’ as fitting within this category.

Discourse 3: Infrastructure access. For Discourse 3 (“Infrastructure Access”), words and phrases focused on how educators spoke about the program’s physical and other methods of access. An example from John: “(We need to go) out of the community. We are the only one that incorporates outside of other high schools” (Interview, 3/17/2015). In this example, John is saying that this The Science Museum program is open to students from schools across the city and not only for students from one particular school. I understand this to mean that John is saying students can access institutions and resources. Within this category, I also included talk about physical structures (cost, location) that were targeted towards particular populations who were understood to not otherwise have access to the Science Museum.

Discourse 4: Motivation / enjoyment, positive affective responses. Coding for Discourse 4 (“Motivation/enjoyment, positive affective responses”) focused on the different words and sentence fragments that spoke about positive experiences and reflections educators had during the duration of the program. This speaks to students taking part in a program because of sheer enjoyment, rather than taking part as a part of an enrichment program that they would complete in order to be more competitive for academic or career purposes. In this category, I included educators talking about their own experiences and reasons for participating in this program. For example, some of them described that they went into the field of education both because they themselves enjoyed it and wanted to share their passion with the youth they worked with. As seen in this example with Mary: “Other than that, all I could say is that students would need more time to become better acquainted with the science and technology” (Interview, 4/2/2015). Even though direct words that would normally be associated with positive experiences are not seen, others are through sentence fragments gathered within the coding sequence. Other parts of the data clearly showed an example of positive experience and emotion, such as this other quote from Ann: “I was excited, I was really excited about the project. I went into it first thinking, mostly because we were supposed to be getting laptops, you know, with the because of the program, I was excited, and I’m always really excited about STEM stuff” (Interview, 3/11/2015). Using words like ‘excited’ consistently was interpreted as an indicator of both feelings and positive experiences.

Discourse 5: Increase access for a select few. Lee’s statement in regards to the program can be used as an example of Discourse 5 (“Increase access for a select few”), which includes the idea of increasing the amount of access for more students to be involved in the program but would require more stringent selection of the students involved: “Not something special itself, just students selected from some of the STEM programs. Maybe a whole program that stood alone by itself, those who are interested could apply" (Interview, 3/11/2015). Here, the language that shows increasing access for a select few is through the phrasing of how access could be expanded but for only certain types of students who would have been interested from the beginning of a program's inception. This is one form of equity that has been seen in other aspects of STEM education, as limited resources may suggest that only students who are genuinely interested and engaged in a subject should be involved in this type of enrichment activity (Dawson, 2014).

While coding the interviews utilizing categories derived from Philip and Azevedo (2017) and Dawson (2014), I compared interview to interview, interviews to students' writing, and interview and students' writing to published documents produced by Science Museum that articulated the program's vision of an explicitly equitable science teaching and learning opportunity for young people in the city of Urban Area. As I compared interview to interview, I compared my a priori codes to both label the ways that educators talked about equity but also to find categories for ways of talking about equity that did not exist in the current codes.

Student artifacts

While students were engaged in learning activities at the Science Museum, students created learning artifacts at the satellite sites. Some examples of the artifacts that were gathered included the online journals that the students' used during their time in the program, as well as the pictures and videos that they had taken of their final projects before they finished the program at the field trip where Operation Space Launch took place, where they launched their balloons into the atmosphere. Artifacts from students' experiences at the satellite sites were collected as examples of students' thinking and understanding as they participated in the Science Leadership Program.

Conclusion

Throughout this chapter, I have introduced the study design and methods of data collection I employed to investigate my research question. This study is presented as an interview study as a result. I collected written artifacts from students who participated in the program, and I also interviewed the educators. In the following chapter, I present analysis of these data and my findings.

Chapter IV: Analysis and Results

Overview

In this chapter, the question that this dissertation sought to answer will be explored through the analysis of data collected. Each category of equity discourse that I have drawn from Philip and Azevedo (2017) and Dawson (2014) will be presented followed by discourse from interviews with educators that I analyzed as fitting within each of these categories as the educators talked about equity in the Science Leadership Program. This chapter will then conclude with an overall summary of the analysis and key takeaways from this research. As described in Chapter III, I have analyzed the interviews and student reflections in order to see how participants understood and spoke about equity.

Research Question:

In a museum outreach program intended to support equitable science learning, how did program designers, educators, and youth participants conceptualize equity in their discourse?

Below, one by one, are the five categories of discourses of equity, with examples from the interview data. As I consider how the educators talked about equity, I will first start by identifying a category that I am borrowing from Philip and Azevedo (2017) or Dawson (2014). Within each category therein, I will first write a summary statement noting how many educators across my pool spoke about equity in this way. After the summary statement, I will provide examples drawn from across the interviews. These examples are not exhaustive. Rather, they serve to show the ways that educators in my data set specifically talked about equity. I will then interpret those statements as fitting within this category. I will do this by first explaining what I understand the quote to mean within the context of the interview. I will then describe how I analyze it as connecting to this particular way of talking about equity.

Equity Discourse 1: Bridging in-school and out-of-school ("Discourses that emphasize increased student achievement and identification with science")

My understanding of Equity Discourse 1. These are the two discourses that I consider in this section of the findings, both of which are identified in Philip and Azevedo (2017). They label these two discourses as Discourse (1) and Discourse (2). I have combined them here for purposes of my analysis as discourses of equity that bridge in-school and out-of-school science learning. In Philip and Azevedo, "Discourse (1) states out-of-school science can be an important bridge for school-based science learning," and "Discourse (2) "states out-of-school science offers more authentic and expansive forms of learning in comparison to most school-based science learning" (p. 528).

This category, what I am calling "Equity Discourse 1," involves both the idea of bridging to school-based learning from out-of-school-based learning (i.e., the concept of "if you do out-of-school science learning, you'll do better in school"; Philip & Azevedo, 2017) and the idea of expanding opportunities to learn outside of school in comparison to school-based science. Many museums and other learning centers taking the approach that students who are passionate about STEM learning will engage in a program with more motivation and interest than students who are less passionate about STEM learning. For this reason, my category of "Equity Discourse 1" also addresses access to a “culture of power” (Au, 2012), where STEM education is accentuated because of its potential of socioeconomic growth for students, especially since, in many cases, learning in school may be seen a non-authentic, while out-of-school gives students a chance to do “real” science.

In my data, I saw that educators talked about “real science” (i.e., science in this out-of-school program) as a way to develop workplace skills and workplace readiness. As these educators talked about STEM learning as access to “real science,” they talked about it as a way of advancement in society, as STEM degrees and careers are not only seen as economically advantageous, but also prestigious (see, e.g., Morgansen et al., 2015). Educators also talked about valuing their own STEM education and recognized the workforce advantages of their own pathways. Most of the educators in my study had a professional background in science and engineering before becoming educators.

Summary of Equity Discourse 1 across my data. For the six educators in my study, they talked about the concept of job readiness as a core part of the program. In other words, for these educators, the doing of science in this program was an opportunity to prepare for potential STEM careers. This was a way of giving them authentic engagement with STEM learning that bridged to and was expansive of their learning in school. There will be three sub-discourses explained in this section as well: educators discussing bridging out-of-school learning to in-school academic learning/success, opportunities to do “real” science outside of school, and educators discussing bridging out-of-school programming to workplace skills and workplace readiness.

Analysis of data that I categorized as fitting within Equity Discourse 1. Below this, I draw from interviews to identify the ways in which the educators in this study spoke about equity as "bridging out-of-school learning to in-school academic success" (i.e., Discourse (1) from Philip and Azevedo (2017). Four of the six educators talked about equity in this way.

1. **Educators discussing bridging out-of-school learning to in-school academic learning/success**

From an analytical perspective, it was an easy bridge to make for educators as they talked about the connections between student success in the program back to their performance in school. Ann said, "I love it, I'm a huge fan of he Science Museum, and love that we have open, after school…(the students) appreciate what we're doing, especially in high school" (Interview, 3/11/2015). I interpreted this to mean that students involved in the Science Leadership Program appreciated what they had been given in their experiences with Science Museum. By "especially in high school," Ann meant that the students were engaging in a challenging subject that could arguably gear them towards a career, as they were nearing the end of their secondary education, and looking for future potential. As this field has been arguably less diverse than others, this connects to equity, as Ann saw potential for her students to expand their horizons through this program with Science Museum. I also understand "especially in high school" to mean that Ann is thinking about the ways that the things students are learning in the program are connected to what they are learning in high school and help them to do well in high school science classes they are taking.

Seeing how much her students flourished in the program was inspiring to Sherry, including seeing how this program could potentially expand to other types of students who could also benefit from this program and subsequently become more engaged and successful in fields that they previously had not participated in. She continued, "Do we have junior high? This leading towards creating STEM flair in the eyes of the younger students would be great, so when they get here, they're ready" (Interview, 3/26/2015). Ann saw that students who had engaged in this type of enrichment program were more ready to succeed and participate in more challenging STEM activities at school and more likely to expand their STEM learning through programs such as the high-school-focused Science Leadership Program. As mentioned by Philip and Azevedo (2017), students who have had exposure to out of school learning, especially when facilitated by educators who are familiar to them, are more likely to engage in challenging STEM learning.

While Ann recognized that students were successful in this program, she also realized that by students having a deeper appreciation for the opportunities that they are given, it would have a deeper impact on how they use this program and similar STEM learning opportunities in and out of schools. The idea of needing additional push into student applications into schools was something that Ann thought of as she discussed her experience with the students. As she continued, Ann stated, "This stuff should really be pushed into the high schools, to start with the scientific process, that's important, to be able to predict and something, to develop hypothesis getting students to understand that it's okay if it's not right, science is, your hypothesis may not be true, I'm always excited about STEM, you know, students realize, get them excited about it" (Interview, 3/11/2015). I interpret here that Ann saw success from her students connecting the program to their academic lives, especially in the concept that their experience of learning how to complete a project from start to finish would be a positive trait to continue in their educational and professional endeavors. In this sentence, I also interpret that she saw both the beginning of the program starting for younger students, who would use their experience into their secondary education, where their skills and experience from the program would help them engage more in depth and prepare them for other, perhaps inevitable, opportunities that would involve project-based learning in and out of school.

Ann also talked about student achievement overlapping in both in and out of school, with a specific attention to leadership potential, and hence, equity, wherein students were more eager and able to achieve in various aspects of life, now that they had confidence after participating in this program. “I think her project will win, on the 25th of April, she’s going to enter it to competition called [retracted], and if she wins, then she will go to next level, if she wins, but I think that project has the potential to take it to the next level. She’s getting excited about that. She’s a freshman now, and I think if she sticks with it, she is really good, but she’s going to be amazing” (Interview, 3/11/2015). Seeing her student’s overall potential augmented through the program, as well as the opportunity to be inspired (a form of passion that will be explored in another category of equity discourse further down), Ann clearly stated the bridge between out-of-school and in-school, as her student was going to be successful in school (“she’s a freshman now”) after being able to learn in this program.

Like Ann, Sherry thought that the best way for a student to truly have the reach of an out-of-school program of this type was to have it start at a younger age, rather than simply select a more talented senior student who had already participated in these types of enrichment activities. This idea of students being able to use their experience of designing a project and carrying it to fruition was one of the ways that both Sherry and Ann thought about doing “real science” as bridging to school experiences and opportunities to learn in school. Ideas and the ability to carry them out were part of traits that they considered prime for carrying into other situations beyond the classroom, a trait that was considered important by Dawson (2014) in terms of ongoing engagement in informal science education, which will be explored in the next sub-question.

2. Opportunities to do "real" science outside of school.

This was a common idea that educators talked about during their interviews, as they saw that the students who they worked with were especially invigorated by the ability to have "guided"--but not "instructed"--science projects. John saw many of his students focus on creating different skills that would develop into useful tools for their potential careers in STEM fields. For example, he said, "Tomorrow they're going to resume writing, or I'll be teaching them resumes, so these two teens I selected, we improved even more to run their full program, [...] once they got their own program they were going" (Interview, 3/17/2015). Seeing the success from the students, John credited it to a sense of independence that came along with doing science in the program. Additionally, even though the participants were fairly independent, they still worked in teams to finish the project. According to John, there were multiple facets of design work that students saw and described, some of which they had to come up with completely on their own: "(The students) formed teams...they have to conceptualize a series of things to make, which also meant using carpentry, then creating a shape/mold, and then they have to come up with the shape of the board" (Interview, 3/17/2015). Using teams and creative concepts in order to problem solve is an idea that is fostered in many informal science education environments, including museums. It is also being used in multiple job-readiness programs as of 2019, with many STEM education programs priding themselves as 'disrupting the industry' (McDonald & Waite, 2019) through creativity and innovation in the workplace, though this concept of job-readiness will be explored later in this paper. In terms of the educators seeing "doing real science" as equity, they talked about job readiness as a goal of access--a way for students to prepare themselves for the future, including preparing themselves for future innovations in the workplace.

Educators talked about this idea of creativity playing a role in student engagement as inspirational from the perspective of STEM education. Students being creative in their project work allowed them to engage in something that truly interested them. This role of creativity was also something that helped the student participants cultivate skills that they would be using outside the program or their high schools. For example, John said, “We are doing design, playing, and teaching teens to be professional. Every time there is someone who does graphics, they need to do layout, shape, photos, programs with different aspects” (Interview, 3/18/2015). John recognized and fostered the skills that he saw as crucial to being successful in the workplace, in future opportunities to learn, and in a future world that might look very different from today’s world, and John used his role as an educator through the Science Museum program to help cultivate these skills in the students he worked with.

Indeed, students who participated in the Science Leadership Program had a very positive, if not mature, response to this program’s impact of their time. For students, being able to identify materials and resources they needed in order to conduct their science projects was one of the things that most of them mentioned in their surveys and reflections they completed after finishing their projects at the end of the school year as an important aspect of the participation. One of the needs they expressed in relationship to conducting experiments as part of their work in the program was the ability for them to conduct science as a professional. The students identified their desire to conduct science “as a professional” as including being able to design their projects and have access to certain materials in order to make their projects come to life. According to one student: “Other experiments, such as mine, I just needed a video recorder because my experiment consisted of two balloons, one with air and one with water, and I wanted to see how much it would expand or even deflate” (Student Artifact, 04/2015). Being able to identify the needs of her science project was the largest part of identification with this student, who was thrilled that she could talk so much about the different science experiments and engineering designs that she was allowed to complete while taking part in this program. The expression of these desires and of satisfaction at being able to conduct “real science” and have choice around the design of their experiments relates to this category of equity discourse because these students saw access to both materials and to their own opportunities to think and design as access to the doing of science, something they expressed a need and desire for in participating in the program.

The student quoted above continued explaining her experience in the program, detailing another experiment that the students were able to design and work on. “In the fall, we also made another experiment called ‘Bottle Crushers.’ It was made to see which crushed bottle, an Ice Mountain 20 oz. water bottle or a Coca-Cola 20 oz. soda bottle, would inflate once sent up near space” (Student Artifact, 04/2015). This experiment allowed students to participate in science and engineering practices similar to those of professionals. When compared to more typical school classroom experiments, the Science Leadership Program allowed students the time and resources to design an experiment and see the project through to its completion rather than be concerned about shorter time in school and the likelihood of a grade being assigned for completing the experiment in a particular way or getting a particular result. Rather, students were basing their success on both the project and the reception from their teammates and educators, wanting to succeed due to social need. This connects to the idea of the discourse category here, wherein students were designing their own research, including the application of success not coming in the form of a good grade, but by the completion of a job well done that could contribute to greater knowledge, much like a professional in science or engineering would do.

This connects to the aforementioned discourse category of ‘opportunities to do real science outside of school,’ in which students are obtaining more experience and thus, are closing the equity gap by being able to successfully practice this type of work on their own.

Overall, being able to have hands-on activities, namely the ones that they were allowed to manage and design themselves, was the aspect of the program that students focused on the most in their artifacts, such as notes and reflections. As part of their reflections on having access to resources and processes to conduct experimental research as professional scientists might, students also mentioned the access they had to supplies and materials that were not available to them in their school classrooms. For example, one student wrote in their reflection, “An experience from the Science Leadership program that will forever be in my memory is when we worked with arduinos. Since the first time I used it, arduinos has been coming up in situations ever since” (Student Artifact, 04/2015). Once this student had access to arduinos (programmable boards that can be used in a variety of electronic design contexts), this student began to see arduino devices and opportunities to use arduino devices in other contexts. This initial access to materials not only opened up this student’s possibilities for practicing science, but also made it possible for them to engage with science and think about the world day to day in ways that were not possible prior to learning about and working with arduinos.

Another student composed a PowerPoint presentation, and recognized that this, although an excellent source of proof of production, was not the same as a final paper. He apologized by way of reflection in his artifact. Being able to recognize his inability to fully submit a product by the end of a deadline was an excellent way of showing that the student knew he had missed the ability to showcase his work in an expected way. One would be curious if the student would have given a similar response if he had a grade rating at the end of this program. However, Dawson’s

(2014) work shows that the ability for a program to be open to a student's struggles with a variety of social issues helps the students cement a sense of confidence in their own ability and that of their peers, as explored below. But, in addition to this concept of ability is the discourse of equity where students who feel capable in their abilities will feel as if they possess the skills to continue to engage in this field.

The examples above show the ways that educators and students talked about equity as the doing of real science in the Science Leadership Program. Educators and students also expansively talked about what "doing science" meant, including a focus on creativity, innovation, independence, workplace readiness, and inquiry-based thinking.

This concept of developing skill sets for workplace readiness and professional STEM practices, including creativity and problem-solving, is something that we will see in the next section.

3. Educators discussing bridging out-of-school programming to workplace skills and workplace readiness.

Workplace readiness was identified by some educators and youth as an important aspect of equity for program participants. Educator Ralph saw his students engage in the program from a practical standpoint, perhaps more so than the other educators interviewed. Ralph said, "One of the focuses of STEM is science, so maybe we could take advantage of some of the engineering aspects, and work on the science of it...that would have been interesting to do" (Interview, 3/26/2015). When asked to expand on this, Ralph went on to explain the different types of engineering that exist in the modern workplace, and the different forms that students could perhaps participate in. Ralph later explained that although his background is in biology, he saw the practical aspects of engineering as a career as well, and encouraged it amongst the students whom he guided in the program at Science Museum.

As Ralph continued, he mentioned the different places and skills that the Science Museum, or other museums that offer STEM learning programs to students, could cultivate among students in order to prepare them for a career once they have finished their secondary education. “Now, culinary college has material science….it would be interesting to have something like that, maybe (partnering with) Boeing” (Interview, 3/26/2015). Like other educators, Ralph saw the program as a way to benefit his students through offering real world activities and enrichment, a way to get them engaged and interested. This also included naming some potential and powerful companies that his students could work with in order to not only gain interest, but experience and connection as well. This could also symbolize the financial and manpower strength of the companies, as finding mentors and opportunities with these types of organizations are being seen as crucial in a post-Recession world in which the importance of career preparation often overshadows holistic enrichment for students.

Ralph continued, “It would be interesting to reach out to companies who have a space division do some engineering, like research and development. Maybe bring in product development, as part of a program, that would be great” (Interview, 3/26/2015). The idea of students performing research as a job was an interesting comment, as Ralph was the only educator interviewed who suggested that students could perform research as a career track, rather than adjacent work skills to be used in something such as design or management. With that being stated, Ralph clearly joined this with the idea of research in the sciences as a career as well.

John had similar thoughts in regards to the selection of students and the resources that were offered to them through the Science Museum, “So these two teens I selected, we improved even more through the year to run their full program, once they got going on their own program they were 100 miles per hour" (Interview, 3/17/2015). For John, as long as the students and himself were given materials and the independence to do their own program and designs, he saw it as beneficial, which can be interpreted that his idea of equity was ground into the idea of students creating their own paths through support, similar to his own career experience and success. As John's pedagogy was both laid back and practical, he was not especially concerned with the program's physical support. Although he was focused on careers through students gaining experience with resumes and work, he was not as concerned with students gaining outside resources as much as other educators were, such as Sherry.

Sherry ended with a similar notion of how students had benefited from the program. Like Ralph, she saw how students could further enrich themselves and their careers through similar actions in these types of programs: "If you contact an office with careers, and that'll probably track with co instructors, automotive or other parts of tracks, just being able to weed out or maybe incorporate different students" (Interview, 3/11/2015). Like Ralph, Sherry came up with the idea of creating opportunities for students to gain experience by working with companies and not just through creating experiments and coming up with creative ideas to share in an out-of-school program like SLP.

Not all educators talked about equity in the SLP in a way that fit within Equity Discourse 1. Both Lee and Mary did not talk about equity as connected to students' bridging experience to work or school, though they both did talk about how participating in a program might lead to students being more engaged in the next out-of-school program they choose to do. The above concludes examples of Equity Discourse 1 from my data. Next, I describe the category of discourse that I am calling Equity Discourse 2: Community Acceptance, and I share examples from the data of educators and youth talking about equity as community acceptance.

Equity Discourse 2: Community acceptance ("Community acceptance as part of a complex system")

My understanding of Equity Discourse 2. In the equity discourse category of Community Acceptance, direction was taken from Dawson's (2014) piece on informal science education and equity. The discourse that I consider in this section of the findings, Community Acceptance, is the "extent to which practitioners are willing to critically reflect on and redevelop infrastructure and resources to accommodate more people" (p. 88). In this category, I looked for educator or student language that exhibited an understanding of equity as an individual or community willingness to critically reflect and then make consequent efforts to accommodate either more students or more enrichment for learners as a result of the reflection. This category of discourse is especially important for an analysis of equity in the Science Leadership Program because the program was designed, in part, to offer access to a Science Museum program for youth across the city who previously were not able to participate in Science Museum youth programming. Science Museum staff were thinking not only of access to Science Museum educators but also access to more in-depth and interesting STEM projects. This intentional effort by Alder program developers at expanding equity fits within this category in terms of a redesign of infrastructure to accommodate more students after reflecting on previous programs. For my study, the category, and analysis of educator discourse within the category, is interesting because I want to understand how educators saw and interpreted the efforts to expand access created across Urban Area by Science Museum program developers.

I understand Dawson (2014) to be saying that talk about equity that fits within the category of community acceptance is recognizable by subsequent efforts to accommodate more participants in programs, including looking at previous experiences and how they might affect other participants in future programs. As educators in my data talked about equity in ways that I categorized as community acceptance, some of them understood equity as opportunities for students to present a final presentation to their peers and the public such that broader communities had access to the work that the students were doing during the program. Other educators talked about community acceptance as opportunities for students to conclude their program experiences with a final project that could be used by multiple members of their communities.

Summary of Equity Discourse 2 across my data. Four of the educators in this study (Ann, John, Sherry, and Ralph) were contracted by the Science Museum to work with students at satellite sites throughout the city, but they did not see themselves as part of the Science Museum. The two Science Museum educators who I interviewed (Mary and Lee), on the other hand, were able to reflect on past programming and on the changes that they had made to expand the program so that more students across the city had access. In this way, their insights are particularly helpful to the category of community acceptance because their thinking and actions include what we might call the complete cycle of community acceptance equity discourse--i.e., implementation of a previous program, critical reflection, and efforts to expand program infrastructures and resources to reach more people.

Analysis of data that I categorized as fitting within Equity Discourse 2. Within this category of equity discourse, I first consider how educators suggested resources and expanded infrastructures. Although my data does not necessarily show the ways that these educators critically reflected on the program's accessibility, the fact that they identified specific resources that could be added to the program in order to accommodate more people shows me that they had critically reflected on the program and its current reach--and, further, that equity was foregrounded in their thinking. Second, I analyze discourse that shows educators talking about how the program opened up equitable opportunities with youth leadership and voice, wherein more opportunities for potential youth interested from the same communities could be made available. The focus on youth leadership and youth voice is particularly important in this category because it shows how the reflective process involves the voices and leadership of young people Science Museum educators say they are trying to reach. In terms of understanding how these educators are thinking about and talking about equity, a focus on youth leadership and youth voice foregrounds community acceptance efforts that are youth-focused.

1. **Educators suggested resources and/or infrastructures to accommodate more students.**

Educators clearly foregrounded reflecting on the Science Leadership Program and considering resources and infrastructures that could be added to accommodate more students. For example, Ann said, "Maybe like, some people from or scientists from the Science Museum could come out to (us), only a couple of times during the summer, and then the students could have the opportunity to visit the Science Museum, and then go and launch the balloon afterwards" (Interview, 3/11/2015). In this part of the reflection, Ann was talking about communication between the main campus of the Science Museum and how it could be expanded in order for students who were in the program to experience Science Museum resources in their satellite sites and at the Science Museum. The expansion of the program through more enrichment activities, such as more scientists coming out to the sites where students are meeting, was another opportunity that Ann saw as a potential for students to take part in. Additionally, she was being critical of existing infrastructure and working to open it.

Sherry mentioned the different resources that could have possibly been available for student enrichment when she said, "I wish more organizations would partner (with) post-secondary or academic opportunities, you know, it would make my job easier, I have a lot of networks, and a lot of program instructors don't have that" (Interview, 3/18/2015). Ann pointed out why she wanted these collaborations to occur. "To supplement and complement programs like organizations for the Science Museum. Get Fermilab… United has reached out to volunteer and I wish that other programs had that support" (Interview, 3/18/2015). Naming different resources for her students was something that Ann did as well. I've categorized this way of talking--making a case for additional resources and infrastructures for future students in the program--as community acceptance because these educators had in mind an understanding of equity that involved building resources and infrastructures specifically in order for students spread out throughout the city to have access to resources that would be available to them at Science Museum proper. Expanding resources and infrastructures in future versions of the current program would inherently accommodate more people because this program was designed to reach out into the city and provide resources that would not otherwise be available to these students.

Ralph had to go to different lengths than the other educators to obtain the biological specimens (in this case, worms) in order for students to engage with the designs that they wanted to create in their experiment. "Teens [...] wanted to put the snails, worms, in space" (Interview, 3/26/2015). Before Ralph worked to get the worms that students requested, they had trouble getting along--arguments that Ralph said came from the lack of resources for students to conduct the experiments they want to conduct. Ralph said, "[There is] great difficulty in re-motivating and hurt feelings….it's kind of a hurdle to get over. It's highly disruptive to motivation" (Interview, 3/26/2015). Getting the resources helped the teens to collaborate. Once they had received the materials, it was easier for them to focus on the work and less on personal differences. In this case, the additional resources accommodated learning for students whose motivation, according to Ralph, was previously disrupted. As an example of Ralph's understanding of equity as connected to access to resources, his response here connects directly to Discourse 2.

Being able to create and nurture relationships with other institutions as an example of additional infrastructures was something that all of the educators in the study talked about, including Mary. She said, "Lastly, I think that the students would be more involved from the get-go if the program started in a lab and experimental setting" (Interview, 4/2/2015). She saw the full enrichment possibilities of students engaging with hands-on experiments in settings or in institutions where these kinds of experiments are conducted. Adding this kind of an infrastructure would open up access for additional students to experiences they would not otherwise have--and likely could not have in schools.

2. Opening up equity with youth leadership and voice.

One aspect of the Science Leadership Program was its intentional focus on leadership. Thus, when talking about equity, program educators addressed the ways in which they tried to cultivate youth leadership and voice as efforts at expanding access for young people not only to resources but also to opportunities to think, inquire, engage, and lead--in other words, opportunities to not just *visit* Science Museum or work with Science Museum educators, but opportunities for youth to participate in scientific practices of a community. In expanding community acceptance through the development of youth leadership and voice, I understand educators to be supporting youth agency and leadership and working towards future possibilities that will include larger numbers of youth participating in programming that is designed by and for youth. As an example of talking about equity in this way, Ann said, "Getting at least one student to participate, she's getting her college applications ready, we have one that completed the whole way through, and putting them in several science fair projects. I think she's gonna win, she's just so different, you know, and it was fun when she got to lead the experiment in the fall" (Interview, 3/11/2015). Students gaining voice through active choice was crucial for Ann in her reflection, as it signified that students were engaged and interested in these types of enrichment programs. Like other educators, such as Sherry, she was concerned that her students in the program were taking on too much, especially as they edged near completion of their secondary education and became even busier as they began their senior years. However, she did recognize that, even if the students were older, they still benefited from taking part. This is connected to Discourse 2, as educators, even with significant concerns about students' time, realized that students leading their own projects was equity in science learning--a way for young people to have access to scientific practices.

Ann continued on how students reacted when the project that they designed while participating in the Science Leadership Program culminated in both the balloon flight and a public presentation. "I think they really enjoyed going out and launching the balloon, more than anything else I could offer" (Interview, 3/11/2015). Here, Ann points out that not only did students have opportunities to express their voices in the design of their experiments, they also expressed their voices to larger publics when sharing their work. Further, these presentations to larger publics were opportunities to celebrate the students' work. As a way of talking about equity as community acceptance, this public sharing and public celebrating affords youth opportunities to adopt science identities, share those identities, and have them recognized and celebrated broadly. In other words, the program has made an explicit effort to see community acceptance as something beyond access to physical structures and resources and to include opening up opportunities for science identity development.

This was similar to Ralph's experience with his students, in which they gave a presentation and felt positive about the experience, "They gave a presentation. Some other students were excited. And they were able to articulate what they had done. They presented to the whole class, it was a high point for them. They're teens and apprehensive about new things. [...] they got to go to [Operation Airlift]. I was pretty excited to compile other things, it was good for them" (Interview, 3/26/2015). By being able to present their findings, articulate their scientific visions, and celebrate their work, Ralph's students were in a similar position as Ann's students. As Ralph talked about his feelings about what his students had been able to accomplish during the program, he focused here on the fact that he saw them as apprehensive about new things before the program but at the program's conclusion able to both articulate science ideas and feel good about what they had accomplished. Again, the possibility for developing positive identities around science and having the time and space to engage in scientific practices of their own design was a way that Ralph saw the program expanding equity by building new communities.

Indeed, the closing ceremony was crucial for Ann's reflection on her student's ability to gain a voice in both presentation and her own confidence in presenting to a non-academic audience in scientific reflection as well. This type of skill is one that is especially needed in modern American popular and political culture, where the ability to comprehend and present challenging scientific findings is hard to find (Suter & Camilli, 2019). Ann said, "I may be being partial, but when I went to the closing ceremony, (student) did a really good job, she did a really good job presenting, her presentation" (Interview, 3/11/2015). Ann's repeated praise of her student's work showed her admiration and pride in her student's ability to use her voice, and shows that she believed the program was successful in its equitable aims by cultivating other voices--new voices to the scientific community and new leaders in engaging in scientific practices.

Mary remarked on the projects that were finished and final field trip to participate in Operation Airlift, "It gives kids a unique opportunity to be involved in the scientific process in an exciting and hands-on way, and depending on the teen could compel them to pursue higher education and STEM fields" (Interview, 4/2/2015). By allowing students to obtain something beyond a good grade (in this case, being able to see their project succeed), which might be the positive outcome of an in-school experience with science learning and doing, students were validated in their process of participation, just as a professional engineer or scientist would be. Mary clearly saw equity as giving these students opportunities for experiments, travel, and growth that would support their development as members of the scientific community and potentially afford them opportunities to continue on a pathway towards professional engagement in science. Mary also talked about the presentations: "All of the students had a functional experiment and gave great presentations on their findings" (Interview, 4/2/2015). Mary felt that by being able to share their research and knowledge, and see their projects that had been funded and supported by the Science Museum "succeed," student participants were rewarded with the powerful message that their work was, indeed, successful and that they could pursue a subject that genuinely piqued their curiosity and passion.

In addition to educators talking about equity as opportunities to grow the scientific community through the Science Leadership Program, students who reflected on their experiences in the program in their open-ended responses to their experiences at the end of the program also talked about equity as connected to community acceptance--meaning, equity as their own development into communities where they were leaders and where they could identify as scientists and participate in scientific practices. Students also saw the development of their own voices and opportunities to share their voices as equitable efforts that I have categorized as fitting within Discourse 2.

For example, one student said, “The most challenging part of the program is coming up with an experiment that you believe will come back with interesting results to yourself and to others” (Student Artifact, 4/2015). By speaking about not only caring about the results for themselves, but also others, this student wrote with language that I have categorized as Discourse 2 because they were concerned about their scientific work as connecting to a broader scientific community. In terms of educators’ goals for the program that equity be developed through supporting students in having access to scientific practices and developing science identities, as exemplified above, this student makes clear that for them this was an outcome of participation in the SLP.

Through communicating and sharing their voices, students displayed the leadership capacities and identities they were also developing in the program. For example, one student wrote about coming up with ideas for their project and being able to effectively communicate ideas with their colleagues: “I helped my fellow program participants to design an experiment by shooting out ideas. We got it down to the top 3 best ideas then picked the best one that everyone agreed on. Everyone enjoyed participating because everyone was engaged and contributing”

(Student Artifact, 4/2015). The way this student talked about being able to effectively discuss ideas in both a group setting of peers and selection of ideas was a sign to me of both leadership and voice by the youth participants.

Finally, students talking in ways that showed their ability to unpack terminology as community insiders by using scientific discourse across multiple contexts and in explanations to strangers in their presentations was evidence to me that the equity goals of the program that I categorized as within Discourse 2 were reached. For example, one student said, “In the summer, in the Science Leadership Program we worked on making experiments to send to near space sent by a weather balloon and a payload box to hold the experiments. Some experiments needed an arduino which collected the data for experiments that needed a computer to keep track of the data” (Student Artifact, 4/2015). In this example, the student clearly utilizes scientific discourse and recognizes the variety in experiments (i.e., that some experiments used computerized data tracking via an arduino) in the program. In this case, by recognizing the diversity in experiments and expertly utilizing scientific discourse to describe the kinds of experiments students in the program were conducting, this students’ language showed her engagement in the scientific community and her own identity as a member of a scientific community.

Equity Discourse 3: Infrastructure access (“Infrastructure access”)

My understanding of Equity Discourse 3. Infrastructure Access was also derived from Dawson’s (2014) research on equity in informal science education. As I analyze this category of equity discourse, I have defined Infrastructure Access as the ways that the educators in the Science Leadership Program talked about equity. Dawson (2014) wrote that Infrastructure Access “would include the physical manifestations of the venues and institutions involved, such as, for example, their location, entry costs, physical entry accessibility, but might also include less literal issues such as marketing strategies, who is and who is not considered as target audiences, or the kinds of staff recruitment processes in place" (p. 216). In my analysis of educators' and students' talk, I have thought about Infrastructure Access as including physical structures (e.g., cost and location of participation in the program), the audience that equity is aimed at for participation in the Science Leadership Program, and also efforts to align educators' lives and experiences with the students Science Museum said they wanted to recruit for this program.

Summary of Equity Discourse 3 across my data. Three educators talked about ways that the Science Leadership Program could involve more students, and two educators specifically talked about reaching out and involving new kinds of students who had not previously participated in the Science Leadership Program. Below, I consider two kinds of discourse that I have categorized within the umbrella of Discourse 3: Infrastructure Access. The first sub-category of Discourse 3 relates to the ways educators talked about student selection for the SLP, and the second sub-category involves how physical structures (including materials) affected access for students to participate in the Science Leadership Program.

Analysis of data that I categorized as fitting within Equity Discourse 3.

1. **Educator talk about student selection for the Science Leadership Program**

Infrastructure Access is a complex category of equity discourse, but the educators in the study agreed that access to the SLP needed to be expanded so that more students could participate in the program. However, the educators had a variety of thoughts about which types of students should be targeted in expansion efforts. They disagreed, for example, about the age, grade, and ability of students who the program should be expanded to include. Sherry had an especially strong opinion of who should be targeted in expansion efforts. She said, "The Science

Museum program could be more for freshmen and sophomores" (Interview, 3/26/2015). Ann mentioned that older students feel a push towards STEM interest and careers as they are looking at post-secondary educational opportunities, but the students who may gain the most benefits from a program like SLP with opportunities and access to physical and material infrastructures are younger students who may already have passion for STEM but who have not yet had experiences engaging in STEM programming and curricula in or out of school. "If I had the opportunity to do it again, I probably wouldn't be with a senior, a graduating senior, because they got so much stuff going on, college essays, they get overwhelmed" (Interview, 3/11/2015). Ann's acknowledgment that age and grade level played a role in student interest, their feelings of success in the program, and their differential opportunities without intentional efforts by educators to target younger-aged youth relates to Discourse 3 because it connects to expanding access to physical infrastructures for audiences that are not currently targeted nor enrolled in the program.

In a continuation of an interview response from Sherry that I included in my analysis of Equity Discourse 2, Sherry talks about the kinds of experiences with Infrastructure Access that would be possible if the Science Museum developed partnerships: "I wish more organizations and energy would partner and give (the students) post-secondary or academic opportunities, it would make my job easier, I have a lot of networks and a lot of program instructors don't have that" (Interview, 3/26/2015). While Sherry notes that because of her extensive professional network she is able to make these kinds of connections for her students--with post-secondary and academic opportunities through partnerships with organizations and companies--other educators do not have this capacity. In talking about possibilities for future programming this way, Sherry is specifically identifying the potential building of relational infrastructures that would give SLP students access to physical infrastructures and other resources (e.g., access to labs, professional settings for scientific practice, workplaces that employ scientists). The connection to student selection here is that these partnerships would open up possibilities for younger students, who Sherry mentions earlier she believes should be targeted for future SLP programming.

Ann also believed that if the SLP expanded its conceptual and topical offerings, there was a possibility that this would attract the younger students she was interested in targeting. In discussing what was possible at the Science Museum, she mentioned another program she was involved with at the same satellite site: “During the summertime, we run programs for kids, in science and math, fingers, doing an engineering project, they got to do an engineering project, and during the academic year, on Saturdays, we do several programs, like a VEX robotics competition, the 1080 student race competition, where we are racing with these remote control cars, doing the science of stem, doing whatever science experiment in the background, doing the science part of it in the background” (Interview, 3/11/2015). Ann argued that a diverse offering of subjects in the Science Leadership Program might attract more interest and a wider potential audience, opening up possibilities for youth who may not have been interested in the current SLP content.

John was pleased with the students he worked with, but he also mentioned a desire to grow the number of students participating in SLP. John believed the program needed to expand participation to include a wider geographic area--bringing in students from greater Urban Area: “(We need to go) out of community. [This site] are the only one that incorporates outside of other high schools” (Interview, 3/17/2015). By ‘we,’ John was talking about his satellite site, which was located at a community center on the West Side, allowing for students from different high schools to work together. While John appreciated that SLP included satellite sites, he felt that access to infrastructure needed to be further expanded so that students from across the wider geographic area of greater Urban Area could participate in a program like SLP.

2. How physical structures and materials affected access to the Science Leadership Program

In analyzing educator interviews, I coded for Infrastructure Access related to this sub-category of physical structures and materials when educators talked about either current students' access to materials and structures or to access by potentially expanded groups of participants. In defining physical structures and materials, I included material resources (e.g., materials purchased by the Science Museum staff to be used by youth in the program) as well as access to the Science Museum itself or to other buildings or sites with resources for STEM learning (e.g., satellite sites with materials that could be used by young people, field trip sites).

In her interview, Ann talked about her own career pathway. She wanted to start off in a STEM career but ended up working in museums, which helped her understand how these places could reach out to underserved communities "I started in the program for, over 25 years ago, and I became, coordinator for our, um, STEM program, uh, so I'm actually the assistant director of the program, and somehow, the projects get real challenging, and I get pulled into so, I got my degree in math, um, some kind of way, I always wanted to be an eye doctor, but life has lead me to being with kids and STEM. Right after high school, (inaudible) the um, Children's Museum, then I was at the Museum of Science and Industry (inaudible) I kept being with kids, I never got to be that optometrist" (Interview, 3/11/2015). In talking about her previous experiences at museums, Ann mentioned how she began working in these types of institutions. This was Ann's initial work with this program style, and while she thought the program did serve students in terms of its outreach to satellite sites, she also thought that Science Museum could have done a better job of providing access to the Science Museum itself for program participants. While she recognized that field trips to the Science Museum would have cut into the time for students to work on their experiments and project designs at their satellite sites in preparation for the end-of-program balloon launch, she still thought the Science Leadership Program didn't do enough to connect program participants to Science Museum's physical resources at the Science Museum itself.

Other educators also talked about equity in terms of youth being able to access the structure of the Science Museum itself. For example, Ann said, "Or the kids could just go to the Science Museum. But more students would be great. So, even to, the awards ceremony, the closing ceremony was really interesting, the kids were so into it, so excited, a really good experience I thought" (Interview, 3/11/2015). Like Mary, Ann recognized the value of outreach to people and communities at a distance from the museum, but she also lamented the lack of access, during a program like this one, to the resources of the Science Museum.

Ralph expressed concern about the students he worked with being able to properly perform what he considered "real" science, and part of that was working more hands-on with actual scientists at the Science Museum itself. With this concern, Ralph gets at the resources available within the physical structure of the Science Museum beyond (or in addition to) material resources. However, like Mary and Ann, Ralph also talked about how his students lived far from the Science Museum and did not have time to cross the city to get to the Science Museum. Ralph noted that if the Science Museum were more centrally located in the city, his students and other people living in the neighborhood where his students lived, would be able to access the physical building of the Science Museum. But because the Science Museum is not centrally located, it was necessary, if young people were going to have any access to the Science Museum's resources, for it to host neighborhood-based programs such as this one.

John, meanwhile, focused on the pedagogical liberty that he had been given by Science Museum staff rather than talking about getting his students to the actual Science Museum's physical structure: "Part of my curriculum is multidisciplinary, and basically part of it as a job readiness program is to improve" (Interview, 3/17/2015). John seemed to think differently from the other educators in that he was not as concerned with his students being able to visit and enter the physical structure of the Science Museum. As he talked about access, he seemed to believe that the physical structure was less important than having resources and materials in his satellite site that students could use. Equity, for John, as it pertains to Infrastructure Access was about opportunities to work with materials and not about opportunities to travel to a physical site.

Mary also noted talked about the materials available to the satellite sites rather than talking about the physical structure of the Science Museum itself as something unavailable to program participants: "The program had all the necessary resources. The one problem I saw--not to look a gift horse in the mouth--was that the laptops that the students used were somewhat slow and fidgety and had a hard time handling the data from the experiments" (Interview, 4/2/2015).

Turning now to student reflections on access to physical structures and resources, students did not mention a desire to be closer to the Science Museum. This was different than the instructors and could indicate that the program was more important than spending time at the actual museum's structure. And although it is possible that students did not mention a lack of access to the Science Museum because they did not know what they were missing, it seems more likely that students were perfectly aware of potential resources at the Science Museum but felt like the things they wanted to be able to do as program participants were all available to them at their satellite sites.

Some students did acknowledge that physical structures of the satellite sites made it difficult to perform some of the experiments that they wanted to perform. For example, one student said, "At first, finding a way to set up experiments to be sent up with the weather balloon was a struggle. We were trying to figure out where to put it to be able to see the experiment and get the data was hard." (Student Artifact, 4/2015). Another student said they had issues with the use of the materials and weather conditions. However, this student also noted that they were able to work through these challenges with materials and weather in order to complete project work: "I am proud of being able to make up an experiment, set it up, test it, and get the results with a very good outcome" (Student Artifact, 4/2015).

Equity Discourse 4: Motivation/enjoyment and positive affective responses ("Literacy: understanding the 'rules of the game' in ISE")

My understanding of Equity Discourse 4. In Equity Discourse 4, I draw on Dawson (2014) to explore how educators and students talked about equity in terms of their own and others' motivation/enjoyment and positive affective responses. Because people who feel frustrated or not included as they learn may not continue to seek out opportunities to learn, whether through a leisure activity or as a profession, it is crucial to consider this discourse of equity. I coded language as fitting in this category when students and educators shared their reasoning for participating in the Science Leadership Program. In doing so, I adapted Dawson's (2014) ISE Literacy framework, in which she defines ISE Literacy as "understanding the 'rules of the game' in Informal Science Education" (p. 223). Dawson expands on her definition in this way: "People need to be able to understand what to do once they are inside a science centre, museum or zoo and, at best, how to maximise the opportunities for enjoyment, learning or socialising therein" (p. 223). As Dawson writes, knowing "the game" of informal science education leads to maximizing enjoyment of learning and doing science. I have included motivation and enjoyment within the framework of Dawson's ISE literacy because as I read and analyzed educator interviews, it was clear that an aspect of equity they talked about was the enjoyment of science experienced by young people. And I understand engagement and enjoyment in these informal science experiences to come once people feel comfortable within them. After feeling comfortable "with the game," learners will engage further for both learning and pleasure.

Summary of Equity Discourse 4 across my data. In reporting findings related to Discourse 4, I only draw on educator interview data. I did not see discursive connections to Equity Discourse 4 in the student responses. Within this category, I do not have multiple sub-categories; I only found educators perceiving student enjoyment and fulfillment--all 6 educators talked about this in their interviews--so this is what I coded as Discourse 4.

Analysis of data that I categorized as fitting within Equity Discourse 4:

1. **Educators perceiving student enjoyment and fulfillment**

Student enjoyment and fulfillment was both one of the easiest and most challenging equity discourses to code for in these interviews as all educators talked about enjoyment and fulfillment, but they also each saw it happen at different times throughout their experiences with students in the Science Leadership Program. Ann reported that she saw enjoyment most noticeably to her when she saw her students participating in the projects themselves, gaining experience that they otherwise would not have had the opportunity to gain. "Both the students enjoyed doing the projects over the summer, like I said, (student) really liked it and kids were looking forward to coming back" (Interview, 3/11/2015). Here, Ann notes the connection between feeling joy and being motivated to continue to learn and engage in science practices and science learning, something she clearly saw as an important element of equitable science teaching and learning.

Ann also recognized that students' capacities for feeling joy and for being what she understood as truly engaged in the program was, in part, a function of their time. This may be the reason that Ann advocated, throughout her interview for younger students to be the focus of future recruiting efforts for the Science Leadership Program. Ann seemed to recognize that equity in science learning was in large part an opportunity to feel motivated, excited, and happy about doing science. In line with Ann's advocacy for younger students as ideally suited for the program, she noted the following about students who were able to enjoy their experiences: "If I had the opportunity to do it again, I probably wouldn't be with a senior, a graduating senior, because they got so much stuff going on, college essays, they get overwhelmed. But for (student), she really enjoyed it, and so did (student). It was just the timing" (Interview, 3/11/2015).

In terms of equitable science learning, Ann's comment about timing reflects one of the most challenging aspects of efforts to expand the reach of museums and Science Museums--namely, that perhaps the people who can enjoy the experiences in informal science learning contexts the most are people who can afford the leisure time to take part in these types of activities. This includes the busy, time-starved high school student, for whom this opportunity might be most enriching only when offered at a certain time in their high school years.

Ann noted that for educators, while enjoyment is a clear indicator that students are engaged and may want to continue with this and future programs, it is also challenging to recognize joy and enjoyment in students and may only be visible at the conclusion of a program like SLP. She said, “If other students wanted to continue, (we) have got to make sure that they can. Our other student, she was enthusiastic and excited, and wow, she loved it. Then, the other student, man, she was quiet. As we go along, we asked her, man, she was excited. Just she was quiet” (Interview, 3/11/2015). Ann thought that all of her students enjoyed the final balloon more than any other aspect of the program: “Every Friday she came back, she was really, excited, telling me, “oh, this was amazing” and she loved it. Other student, she was quiet. Not as excited to share it. And alive with her. As go along, asked to continue, she was excited. And you can tell, from that day, that she was excited about it. She’s just a little bit quieter” (Interview, 3/11/2015). Like Ann, John said the conclusion of the program was when he saw his students express joy at participating in the program: “They had a great time. We had them do a little showcase about the project, then about what they learned, and the presentation was great! You could just feel the energy” (Interview, 3/17/2015).

While Mary recognized the enjoyment that her and other students had while participating in the Science Leadership Program, she also addressed frustrations and challenges that her students faced while participating in the program. For example, she said, “Other than that, all I could say is that students would need more time to become better acquainted with the science and technology” (Interview, 4/2/2015). Specifically, Mary said that although her students “enjoyed making the Arduino SIK experiments, the students, having little or no computer science background, could not be expected to understand the coding and circuitry behind their experiments” (Interview, 4/2/2015). As a way of talking about equity, Mary’s attention to challenges and frustrations that occurred along the way during the program are important. Her students, too, expressed joy and enjoyment at the conclusion of the program, but that joy does not erase their feelings of frustration during the program, and Mary believed there were ways to make the program more enjoyable week to week so as to build on students' feelings of happiness and motivation as they moved through the program rather than watch them struggle because the program was not designed as well as it could have been. For example, Mary could identify one change she could have implemented to improve the affective experience of her students: "What I think happened was that we were too ambitious with the fall. For the next program, they will come up with an experiment" (Interview, 4//2/2015). What Mary means here is that some structure at the outset would have better supported her students in their work--for example, if they had come up with an experiment first rather than exploring the different options that they could research.

Equity Discourse 5: Increase access for a select few ("Privilege in Science")

My understanding of Equity Discourse 5. In defining Increasing Access for a Select Few I contrast this way of talking about equity with Philip and Azevedo's (2017) third discourse of equity, which they describe as efforts to "expand notions of what constitutes science--who does science and in what contexts--and how they might be productively leveraged in science learning" (p. 528). Philip and Azevedo write that "the theory of change that underlies (this discourse) is that changing what counts as science will make science more pluralistic and responsive to the needs, hopes, and struggles of different communities." I introduce Philip and Azevedo's third discourse here to point to the ways that a program like SLP could have been one that sought for this vision of equity. In some ways, the educators did want young people's voices, leadership, and efforts in the Science Leadership Program to be seen as a move towards expanding what counts as science and reflecting the hopes and needs of their lives and their communities. And although my analysis has shown some of the educators' thinking along these lines, this particular Equity Discourse--Discourse 5 is a counter to all of that. In talk that I categorized as fitting within Discourse 5, rather than thinking expansively about who could do science and what could count as science, educators talked about needs to *constrain* who could participate in SLP. In other words, this particular discourse reified rather than sought to disrupt "Privilege in Science." For example, educators' talk that I categorized as Discourse 5 included desires to only invite students who were well behaved, obtained good grades, or had expressed passionate interest in STEM to participate in the Science Leadership Program.

Summary of Equity Discourse 5 across my data. Student artifacts did not include any mention of constraining who could participate in the Science Leadership Program, so I have not used their responses in analyzing discourse in this category, whereas all of the educators in one capacity or another spoke about how different populations of students could be served. Educators did talk about choosing particular participants in order for them (and for the educators) to have the best experience. In two sub-sections below, I consider each of the two sub-categories I coded for underneath Increasing Access for a Select Few. In the first sub-section, I include examples of educators' language about choosing passionate participants rather than high achieving or academically strong participants. These educators talked in their interviews about passion being the best indicator that student (and educator) would have a positive experience in the Science Leadership Program. In the second sub-section, I include examples of language that I categorized as discussing how educators might have better selection processes for choosing participants. Because Discourse 5 is about seeing equity as the expansion of participation only for a select few participants who fit some established criteria, both of these subsections deal with educators identifying criteria and considering processes for choosing participants who fit within those criteria.

Analysis of data that I categorized as fitting within Equity Discourse 5:

1. **Choosing passionate participants**

As I have tried to make clear throughout this chapter, educators did want to see the Science Leadership Program expanded. Their visions of equity all included extending the Science Leadership Program, or programs like SLP, to broader participant pools. For example, Ann said, "I would like to see of my more students in it. I liked it. It was really well run! Have all of that...access! Student was really loving how she could get resources, it would have been amazing. I wish more students would have been involved, it would have been amazing" (Interview, 3/11/2015). Many, if not all, informal science education facilities want to foster an environment for engaging diverse groups of young people as museums de-colonize their collections and create inclusive learning environments that serve to educate multiple audiences. However, in Discourse 5 I have gathered talk that argued for expansion only to select participants.

For example, Lee, who saw that the students were engaged and interested in the program, still had reservations about how this affected the students who he worked with throughout the year. "It worked out well. However, when we think about conditions when we got to work with students directly, we got results." (Interview, 3/17/2015). When Lee mentions "conditions" here, he was thinking in part about the group of students that he worked with. It made a difference in the learning opportunities of the whole group how invested each of his students were in the Science Leadership Program.

Lee thought that the educators might attend other science events in the city in order to find students who would be more passionate about science already before they even joined the Science Leadership Program. For example, he had in mind recruiting at events passionate teens might already be attending. He said, “If we went to Hack Day, it would reach more STEM attentive students, but they would need that initial interest. Citizen Science (the website run by The Science Museum) has helped us learn a lot” (Interview, 4/2/2015). Both Citizen Science (Sieber & Slonosky, 2019) and Hack Day are examples of two informal science education activities that do not require extensive knowledge of the subject before an individual participates. Recruiting students at these events would not necessarily mean finding the strongest academically prepared young people. Rather, it would ensure that students recruited to participate in the Science Leadership Program were passionate about science. These events are also reflective of a democratic ideal of seeking passionate students rather than simply high performers who may be seen as ‘earning’ the right to an enriching program hosted at a place like the Science Museum.

Mary also thought that the idea of selecting student participants who were prepared to participate was crucial to keeping a museum program viable, but like Lee, she also saw the benefit of selecting students based on passion rather than performance. Mary said, “I also strongly believe that the program would benefit from an application process of selecting students” (Interview, 4/2/2015). Mary recognized that for most of the participants, it was very challenging to work and wait until the day of the launch came. “Though the entirety of the group was excited by the launch, about half of the students were not interested in participating in much of the preliminary parts of the program” (Interview, 4/2/2015). Mary believed that students who joined the program with a pre-developed passion for STEM and science learning would be able to work through the design phases of the program with an eye towards the launch but with passion and excitement throughout all the weeks of the program.

2. Educator plans to improve selection processes and choose successful participants

Mary and John were both concerned about the need to identify and recruit students who could fully commit to a program hosted by the Science Museum. Mary recalled her experiences with the students she oversaw and said, “I could do a better job and being able to find students that could commit” (Interview, 3/11/2015). Ann continued, “I think it would be great, what I found, is given the kids who want to be there is so key” (Interview, 3/11/2015).

Chapter V: Discussion and Conclusion

Overview

In this chapter, I will summarize the study and findings and then discuss the implications of this study in relationship to ongoing scholarship. I will then identify limitations, suggest further research, and make recommendations for relevant practitioner audiences based on my study.

Summary of the Study and Findings

It is clear that the Science Museum, like many museums, is working on expanding its outreach efforts and being inclusive. Summarized here, the Science Museum's vision is to connect people and communities through the wonder of science to create a better world. Among other things, the Science Museum explicitly values inclusivity, diversity, empathy, and accessibility. As part of their vision and values, the Science Museum is working to expand their reach into and beyond Urban Area. As I have described in the introduction to this dissertation, Science Museum staff created the Science Leadership Program as an intentional effort to broaden the reach of Science Museum programming. The Science Leadership Program included at least a couple of innovations with the intention of expanding access to Science Museum staff and resources: first, the program took curricula that had been piloted in a school-based program and expanded it to be used in an out-of-school setting. Second, the Science Museum utilized educators who were situated in community-based sites in neighborhoods far from the Science Museum as hosts for satellite programming accessible to youth in those neighborhoods.

Although Science Museum program planners and Science Museum administrators who set the vision for the Science Museum and have worked to expand outreach did not use the word "equity" in official communications describing their efforts, it is also clear that the Science Museum's work in this regard aligns with what Philip and Azevedo (2017) described as the promise of out-of-school settings: "to broaden participation in science to groups that are often left out of school-based opportunities" (p. 526). Philip and Azevedo note that these efforts to broaden participation are "premised on the notion that science is intricately tied to the 'social, material, and personal well-being' of individuals, groups, and nations (NRC, 2009)--indicators and aspirations that are deeply linked with understandings of equity, justice, and democracy" (p. 526). As they introduce their work to describe the ways that the concept of equity in the field of out-of-school science teaching and learning is operationalized, Philip and Azevedo write that "the very conception of equity in the field is a moving target, shifting widely in meaning across contexts and research perspectives" (p. 526).

As I have discussed in the opening chapters of this dissertation, Philip and Azevedo's (2017) consideration of everyday science learning and equity inspired the focus of my analysis of interviews collected from The Science Museum educators who had been involved in the Science Leadership Program. Through this analysis, my intention was to empirically explore the different ways that The Science Museum educators and student participants talked about the concept of equity after participating in a program that was intentionally designed to expand equity. Following Philip and Azevedo's (2017) use of the term, I have called these ways of talking about equity "discourses of equity." I analyzed the discourse in interviews with six educators who worked in satellite sites as part of the Science Leadership Program or were employees of the Science Museum proper and were educators as part of the Science Leadership Program. I also analyzed the discourse in student artifacts that were completed by student participants in the Science Leadership Program after they had completed the program. I analyzed discourse from the interviews and student responses utilizing five categories, each adapted either from Dawson (2014) or Philip and Azevedo (2017):

- Equity Discourse 1: Bridging in-school and out-of-school ("Discourses that emphasize increased student achievement and identification with science")
- Equity Discourse 2: Community acceptance ("Community acceptance as part of a complex system")
- Equity Discourse 3: Infrastructure access ("Infrastructure access")
- Equity Discourse 4: Motivation/enjoyment and positive affective responses ("Literacy: understanding the 'rules of the game' in informal science education (ISE)")
- Equity Discourse 5: Increase access for a select few ("Privilege in Science")

I coded sentences and phrases within the interview transcripts and student artifacts as fitting within one of these five categories. In the dissertation, I have presented examples from the interviews and student artifacts to identify the ways that I understood educators and students in this study to be talking about equity.

Implications of the Findings

In the following five sections, I address the implications of this dissertation for ongoing teaching and research in out-of-school science education.

The political nature of out-of-school science teaching and learning. Educational researchers, learning scientists, and curriculum studies scholars regularly study science learning in out-of-school museum programming similar to the Science Leadership Program offered by the Science Museum (e.g., Kisiel, 2006b). Within the last twenty years, since the National Science Standards was published in 2000, through efforts to expand participation in these kinds of programs, researchers and practitioners have focused on ways to address educational inequities. A challenge to this kind of work has been defining and understanding how practitioners view equity and what they are thinking about as they work to expand program access. The perspectives out-of-school science educators bring to the work of educational justice, equity, and democracy is important to consider because everyday science learning is political. At the time of this writing, discussions in the public sphere about global climate change, energy policy, fossil fuel extraction, alternative energy sources, genetic testing, vaccines, and many other scientific discourses are central to political debates and public policy. As out-of-school educators continue to expand their efforts to reach youth, how do they view their work as political? How do they understand equity? What do they see as their priorities and their expertise? What role does curricula play in supporting young people to participate in democratic and civic processes? This dissertation study is a small step in the direction of working to understand conceptions of equity in the contested spaces of everyday science learning (Philip & Azevedo, 2017).

Mentorship in out-of-school science education programming. By organizing students into small peer groups at satellite sites and providing mentors to support their inquiry projects and science learning, Science Museum program creators and educators worked to combat a contemporary educational challenge that young people often struggle to find adult mentors (Anyon, 1997). Au (2009) writes that of the many barriers for students to succeed in their respective fields, a dedicated mentor is essential. This is especially true for adult mentors whose lives and backgrounds connect to or relate with the young people they mentor. In my interviews with educators, their conceptions of equity, and the ways they talked about expanding opportunities for young people were closely related to their own academic, career, and science identity development pathways (see, e.g., Beilock, 2010). When program participants do not feel as if they belong, or that they are not represented in a learning space, then they are less likely to participate or return to the program as a result (Griffin, 2004).

Interest-driven science learning. As I wrote in Chapter IV, several SLP educators said the program should include a larger number of students but that those students should be more carefully chosen. While somewhat disheartening to reflect on this notion of selectivity, it also speaks to a greater need, which is that of a larger, more engaged body of students to take part in this type of a program. By making this program more available for additional young people, it can attract a more diverse and more engaged group of participants who are genuinely interested in science and STEM learning. Identifying and involving young people in programs like the SLP is important because supporting the development of a workforce that is engaged and interested in STEM professions is one of the equity goals expressed by out-of-school science program providers and educators.

Access to museum resources. One of the equity efforts of the Science Museum and other science museums is to open up access to museum staff and resources to people who are at a geographical distance from the museum. Witcomb (2003) mentions in her studies of museums and families that families are more likely to visit museums if they have easy access to an urban center and the ability to consistently engage with regular programming. The creation and implementation of the Science Leadership Program was an attempt, among many others, to reach out to marginalized groups who previously had not engaged with the Science Museum (Witcomb, 2013) and to extend museum resources into communities so that people participating in programming would not have to come to the Science Museum building.

Development of young people's science identities. Both educators and the youth who took part in the Science Leadership Program talked about how SLP youth developed their voices as communicators of science, their capacities as leaders, their facility with research design and enactments, and their identities as scientists. Youth and educators felt like youth were able to develop confidence as subject matter experts and understood how to use available materials to conduct scientific inquiry. A key part of young people's development of science identities was their engagement in science practices. While electrical and mechanical engineering are not commonly offered as school classes for secondary-aged American students (Apedoe et al., 2008), engineering is an applied subject for many informal science experiences, and other forms of engineering, such as computer or other forms of software, are becoming more standard in the 21st century classroom (Beetham & Sharpe, 2013). Clearly, in the Science Leadership Program, both educators and students reported that students took up opportunities for developing STEM identities.

Limitations

The limitations of this study were typical of a study of teaching and learning involving a small group of youth and educators (Yoon et al., 2012). However, a study with a small number of participants was beneficial, as I was able to analyze the talk of everyone involved in the program. One limitation specific to this study was the fact that I did not interview all of the students. For their conceptions of equity, I relied on their written reflections. I also did not conduct ethnographic observations, which would have added additional insights into the talk and thinking of students and educators about equity. For myself, I would have preferred to be a participant-observer or action researcher in the study, taking a more hands-on role as an educator and a researcher. I say this both as a reflection of my current work experience and my previous experience as an educator at multiple museums. Unfortunately, due to constraints at the university and with my job as an evaluator, I was unable to design the study in this way.

Suggestions for Further Research

My first suggestion for further research would be to conduct a future study of the SLP, or other Science Museum programs, that include interviewing students who participated in the programs, which I had hoped to do with this study but could not due to challenges with IRB. With additional in-depth conversations with student participants, future researchers will be able to better understand young people's conceptions of equity.

I hope future studies will also be able to follow a two-year program with the same students. Because the majority of out-of-school science learning programs, especially at the pilot stage, have year-long programming, it may not be possible to follow one group of students across multiple years. If this is the case, I think following discourses of equity across different cohorts of students participating in the same program in different years would support the field's further understanding of conceptions of equity among out-of-school science educators and young people engaged in programming.

Recommendations based on findings from this study.

Below, I identify two recommendations for practitioners based on the findings from my research.

1. Recommendations for out-of-school science educators and administrators. I would recommend for out-of-school educators to design programs that involve educators who live in or otherwise identify with the communities the programs are intended to serve. As can be seen with the responses of the educators who taught in the communities they identified with and/or lived in (Sherry, Ann, and John), both educators and young people felt that this was an important aspect of the Science Leadership Program. From this, recommendations would include being able to reach out to community members, as well as local students, to not only see the challenges that are being faced, but also the aspirations. For many, careers in science and other STEM fields are seen as economically powerful driving factors rather than intellectual fulfillment. As I have since moved on from the Science Museum and now oversee a large STEAM program, I have seen this type of program design for out-of-school learning flourish in multiple neighborhoods around Urban Area through organizations such as Urban Area learning networks, where museums seek out different community partnerships to better serve a large and diverse population across geographically distributed neighborhoods.

In my own program with the Boy Scouts of America, we seek out community partners who know and love the members of their communities, and we both train them and give them materials in order to support their own out-of-school learning. As a result, we have both expanded our programs and retained youth participants. By being able to not only expand the program by including more options for geographic boundaries (training local volunteers, offering WiFi hotspots for Internet, observing different holidays and school schedules for meetings, etc.), but also for including more of the community in the creation and implementation of programs, museums can become places for supporting empowerment across communities.

I recommend out-of-school science teaching and learning administrators, including directors, development professionals, and others who promote and work in museums and other nonprofits also seek to deeply involve communities where programming is located. Since the publication of the National Science Standards in 2000, there has been a significant change of direction that focuses less on the museums themselves, and more on the greater community that they serve, at least in the greater Urban Area. By involving participant voices such as councils for teens and other groups, increasing diversity on boards and staff, and even taking part in such movements as ‘Occupy Wall Street’ and the #MeToo movement, administrators can make their programming more accessible and engaging to multiple audiences, thus following the voices in this research on equity.

2. Recommendations for parents and their students participating in out-of-school science programs. A recommendation for parents and their students who are participating in out-of-school science programs would be to know both the program goals and the participant's own goals. For some young people, their goals for participating in the program might involve better preparing for college applications, while others might be pursuing mental or emotional support. Other participants may be seeking social connection, as Ralph mentioned in his interview. With these individual participant goals in mind, museums and their programs can become powerful tools for experiential learning, offering opportunities such as field work, classes, professional development, and connections that can help disenfranchised young people gain needed interest and experience in order to become interested in this type of academic and career pursuit. However, it should be noted that, as Ann stated above, students who are nearing the end of their secondary education, such as high school juniors and seniors, may face the possibility of struggling to balance one more activity on top of another. Being able to find a program that is both innovative but time sensitive is an ongoing challenge, as many museums have storied volunteer programs for interpreters and assistants, but require a certain amount of hours in order to keep the position. Additionally, although there are now options for students above the age of 16 to be paid either stipends or a wage for their work, many places that offer experiential learning in these types of environments require volunteer service, which may deter students who financially support themselves and/or their families, thus creating a further disadvantage for students. Being able to assess what the program offers, what the role the student will be in, and what both parties have to gain will best support young people and parents in participating in these kinds of programs.

Conclusion

Museums and other sites of out-of-school science education evolve alongside the needs of the communities and people they serve. As more museums and other educational organizations seek new and innovative ways to educate and curate their collections, they will likely also continue to talk about the goals of equity, diversity, justice, and democracy in science teaching and learning. This dissertation study has attempted to explore the “sites of contestation” (Philip & Azevedo, 2017) in, around, and through the Science Museum and one of its programs, the Science Leadership Program in an effort to consider how educators and young people think about the concepts and goals associated with equity. In analyzing discourses of equity, I hope to contribute to ways equity not only gets talked but also gets walked.

Appendix A

Sample Interview Questions

1. What is your background?
2. How long have you worked with the Science Museum?
3. How did you come to work for the Science Museum?
4. How can you describe the experience of the students?
5. Tell us about a memory of the students in the program.

6. What is the growth that you saw of the students in the program?
7. What was the biggest challenge?
8. What was the biggest achievement?
9. What could you have changed?
10. Any other questions or comments for us?

Appendix B

Interview Protocol

Interview Protocol
Locations: ____
Interviewee (Title and Name): _____________________________________
Questions Used:
_____ A: Interview Background
_____ B: Institutional Perspective
_____ C: Assessment
_____ D: Department and Discipline
_____ E: Teaching and Learning
Other Topics Discussed:____

Bibliography

Adams, R. (2001). *Sideshow USA: Freaks and the American cultural imagination*. University of Urban Area Press.

Science Museum Mission and Values. (2019). Retrieved from https://www.the Science MuseumScience Museum.org/about-us/the Science Museum-mission/.

Anderson, D., Lucas, K. B., & Ginns, I. S. (2003). Theoretical perspectives on learning in an informal setting. *Journal of Research in Science Teaching*, *40*(2), 177–199.

Apedoe, X. S., Reynolds, B., Ellefson, M. R., & Schunn, C. D. (2008). Bringing engineering design into high school science classrooms: The heating/cooling unit. *Journal of science education and technology*, 17(5), 454-465.

Apple, M. (1982). *Education and power*. Boston: Routledge & Kegan Paul.

Apple, M. (1979). *Ideology and curriculum*. London: Routledge & K. Paul.

Ash, D. (2003). Dialogic inquiry in life science conversations of family groups in a museum. Journal of Research in Science teaching, 40(2), 138-162.

Au, W. (2012). *Critical curriculum studies: Education, consciousness, and the politics of knowing*. New York: Routledge.

Au, W. (2009). *Unequal by design: High-stakes testing and the standardization of inequality*. New York: Routledge.

Anyon, J. (1997). *Ghetto schooling: A political economy of urban educational reform*. New York: Teachers College Press, Teachers College, Columbia University.

Azevedo, F. S. (2013). The Tailored Practice of Hobbies and Its Implication for the Design of Interest-Driven Learning Environments. *Journal of the Learning Sciences*, *22*(3), 462–510. doi:10.1080/10508406.2012.730082

Bailey, J.M., and Slater, T.F., 2003, A review of astronomy education research: Astronomy Education Review, v. 2, no. 2, p. 20–45.

Bailey, J.M., and Slater, T.F., 2005, Resource letter on astronomy education research: American Journal of Physics, v. 73, no. 8, p. 677–685

Beetham, H., & Sharpe, R. (Eds.). (2013). Rethinking pedagogy for a digital age: Designing for 21st century learning. Routledge.

Beilock, S. L., Gunderson, E. a, Ramirez, G., & Levine, S. C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(5), 1860–3. doi:10.1073/pnas.0910967107

Boswell, D. & Evans, J. (1999) *Representing The Nation:* A Reader Oxford, Routledge

Bonnett, M. (2017). Environmental consciousness, sustainability, and the character of philosophy of education. *Studies in Philosophy and Education*, *36*(3), 333-347.

Buenker, J. D., (2002). *The Gilded Age and Progressive Era, 1877-1920*. Copley Publishing Group.

Bynum, Y. P. (2015). The power of informal mentoring. *Education*, 136(1), 69-73.

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of research in science teaching*, 44(8), 1187-1218.

Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative analysis*. Sage Publishing.

Dawson, E. (2014). Equity in informal science education: developing an access and equity framework for science museums and science centres. *Studies in Science Education*, 50(2), 209-247.

DeBoer, G. E. (2000). Scientific literacy: Another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *37*(6), 582-601.

Delpit, L. (1988). The silenced dialogue: Power and pedagogy in educating other people's children. *Harvard educational review*, 58(3), 280-299.

Delpit, L. (1995). Teachers, culture, and power: An interview with Lisa Delpit. *Rethinking schools: An agenda for change*, 136-147.

Dierking, L. D., Falk, J. H., Coeditors, S., Bamberger, Y., & Tal, T. (2006). Learning in a Personal Context : Levels of Choice in a Free Choice Learning Environment in Science.

Dodd, J., Jones, C., Jolly, D., & Sandell, R. (2010). Disability Reframed: Challenging visitor perceptions in the museum. In *Representing Disability: Activism and Agency in the Museum* (pp. 92–110).

Edelson, C. (2011). What We Learn When Design Research : We Engage in Design, *11*(1), 105–121.

Emdin, C. (2007). Exploring the contexts of urban science classrooms. Part 1: Investigating corporate and communal practices. *Cultural Studies of Science Education*, *2*(2), 319-350.

Evans, R. I., Rozelle, R. M., Lasater, T. M., Dembroski, T. M., & Allen, B. P. (1970). Fear arousal, persuasion, and actual versus implied behavioral change: new perspective utilizing a real-life dental hygiene program. *Journal of Personality and Social Psychology*, 16(2), 220.

Falk, J. (2004). The director's cut: Toward an improved understanding of learning from museums. *Science Education*, *88*(S1), S83–S96. doi:10.1002/sce.20014

Falk, J. H., & Dierking, L. D. (2008). Enhancing visitor interaction and learning with mobile technologies. Digital technologies and the museum experience: *Handheld guides and other media*, 19-33.

Falk, J. H., & Dierking, L. D. (2018). *Learning from museums*. Rowman & Littlefield.

Falk, J. H., & Storksdieck, M. (2009). Science learning in a leisure setting. *Journal of Research in Science Teaching*, *47*(2), n/a–n/a. doi:10.1002/tea.20319

Fensham, P. J. (1985). Science for all: A reflective essay. Journal of curriculum Studies, 17(4), 415-435.

Florio-Ruane, S. and Morrell, E. (2011). Discourse Analysis: Conversation. In N.Duke and M. Mallette.Literacy Research Methodologies. New York: Guilford,Completely revised second edition

Fox, P.(1933). Astronomical Museum. *An Account of the Optical Science Museum and a brief Guide to the Museum. Urban Area*.

Gee, J. P. (2011). *An introduction to discourse analysis: Theory and method*. Routledge.

Genoways, H. H., & Ireland, L. M. (2016). *Museum Administration 2.0*. Rowman & Littlefield.

Glassberg, D. (1990). *American historical pageantry: The uses of tradition in the early twentieth century*. UNC Press Books.

Gledhill, J. (2012). Collecting Occupy London: Public collecting institutions and social protest movements in the 21st century. *Social Movement Studies*, *11*(3-4), 342-348.

Grant, C. M., & Ghee, S. (2015). Mentoring 101: Advancing African-American women faculty and doctoral student success in predominantly White institutions. International Journal of Qualitative Studies in Education, 28(7), 759-785.

Gresalfi, M., Martin, T., Hand, V., & Greeno, J. (2008). Constructing competence: an analysis of student participation in the activity systems of mathematics classrooms. *Educational Studies in Mathematics*, *70*(1), 49–70. doi:10.1007/s10649-008-9141-5

Griffin, J. (2004). Research on students and museums: Looking more closely at the students in school groups. *Science Education*, *88*(S1), S59–S70. doi:10.1002/sce.20018

González-Díaz, O, (2018), *I was raised on the Internet* [3D visual piece], Exhibited at the Museum of Contemporary Art, June 23, 2018 - October 14, 2018

Gutwill, J. P., & Allen, S. (2012). Deepening students' scientific inquiry skills during a science museum field trip. Journal of the Learning Sciences, 21(1), 130-181.

Halverson, E. R. (2013). Digital Art Making as a Representational Process. *Journal of the Learning Sciences*, *22*(1), 121–162. doi:10.1080/10508406.2011.639471

Herron, M. D. (1971). The nature of scientific enquiry. The school review, 79(2), 171-212.

Jimenez Pazmino, P., & Lyons, L. (2011). An exploratory study of input modalities for mobile devices used with museum exhibits. *Proceedings of the 2011 Annual Conference on Human Factors in Computing Systems - CHI '11*, 895. doi:10.1145/1978942.1979075

Kahler, M. (2015). Networked politics: agency, power, and governance. Cornell University Press.

Kelly, G. J., Carlsen, W. S., & Cunningham, C. M. (1993). Science Education in Sociocultural Context : Perspectives from the Sociology of Science, *1991*(2), 207–220.

Killewald, A., & Xie, Y. (2013). American science education in its global and historical contexts Bridge, 43(1), 15-23.

Kisiel, J. (2006a). An examination of field trip strategies and their implementation within a natural history museum. *Science Education*, *90*(3), 434–452. doi:10.1002/sce.20117

Kisiel, J. (2006b). Urban teens exploring museums: Science experiences beyond the classroom. *The American Biology Teacher*, 68(7), 396-401.

Kliebard, H.M. (2001). *The struggle for the American curriculum, 1893-1958*. New York: Routledge & Kegan Paul.

Kliebard, H. M. (1999). *Schooled to Work. Vocationalism and the American Curriculum, 1876-1946. Reflective History Series*. Teachers College Press New York, NY

Litman, J. (2005). Curiosity and the pleasures of learning: Wanting and liking new information. Cognition & emotion, 19(6), 793-814.

Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among US students. Science Education, 95(5), 877-907.

Marche, J. (2005). *Theaters of time and space: American planetaria, 1930-1970*. Rutgers University Press.

McDonald, K. S., & Waite, A. M. (2019). Future Directions: Challenges and Solutions Facing Career Readiness and Development in STEM Fields. Advances in Developing Human Resources, 21(1), 133-138.

McGill, S. A. (2005). *WEB Du Bois*. Great Neck Publishing.

Milner, H. R. (2012). But What is Urban Education? Urban Education, 47(3), 556–561. https://doi.org/10.1177/0042085912447516

Monk, D. F. (2013). John Dewey and Adult Learning in Museums. *Adult Learning*, *24*(2), 63–71. doi:10.1177/1045159513477842

Moreno, N. P. (2019). Strengthening Environmental Health Literacy Through Precollege STEM and Environmental Health Education. In Environmental Health Literacy (pp. 165-193). Springer, Cham.

Morganson, V. J., Major, D. A., Streets, V. N., Litano, M. L., & Myers, D. P. (2015). Using embeddedness theory to understand and promote persistence in STEM majors. The Career Development Quarterly, 63(4), 348-362.

National Research Council. (2000). Inquiry and the national science education standards: A guide for teaching and learning. National Academies Press.

Nguyen, N. (2016). A curriculum of fear: Homeland security in US public schools. Minneapolis: University of Minnesota Press.

Nisbet, M. C., & Markowitz, E. (2016). Science Communication Research: Bridging Theory and Practice. American Association for the Advancement of Science, Washington, DC.

Office of Science and Technology Policy. (2017, September 20). Retrieved June 10, 2018, from https://www.whitehouse.gov/ostp/

Parasuraman, R., & Riley, V. (1997). Humans and automation: Use, misuse, disuse, abuse. Human factors, 39(2), 230-253.

Philip, T. M., & Azevedo, F. S. (2017). Everyday science learning and equity: Mapping the contested terrain. Science Education, 101(4), 526-532.

Pomeroy, E. (1999). The teacher-student relationship in secondary school: Insights from excluded students. British journal of sociology of education, 20(4), 465-482.

Raudenbush, S. W. (2005). and Comment Learning from Attempts to Improve Schooling : The Contribution of Methodological Diversity, (July), 25–31.

Reeder, D. (1980) *Educating Our Masters*. Leicester: Leicester University Press

Resnick, M., & Rusk, N. (1996). The Computer Clubhouse: Preparing for life in a digital world. *IBM Systems Journal*, 35(3.4), 431-439.

Rudolph, J. L. (2005). Inquiry, instrumentalism, and the public understanding of science. *Science Education*, *89*(5), 803–821. doi:10.1002/sce.20071

Sanders, M. (2009). STEM, STEM Education, STEM Mania. *The Technology Teacher*, 20–26.

Schwartz, D. F. (2005). Dude, where's my museum? Inviting teens to transform museums. *Museum News*, 84(5), 36.

Seixas, P. (1993). The Community of Inquiry as a Basis for Knowledge and Learning: The Case of History. *American Educational Research Journal*, *30*(2), 305–324. doi:10.3102/00028312030002305

Sieber, R., & Slonosky, V. (2019). Developing a Flexible Platform for Crowdsourcing Historical Weather Records. *Historical Methods: A Journal of Quantitative and Interdisciplinary History*, 1-14

Spring, J. (1974). Unionism and American Education. *AERA Meeting Paper*.

Stevens, R., & Hall, R. (1997). Seeing Tornado : How Video Traces Mediate Visitor Understandings of (Natural ?) Phenomena in a Science Museum. *Science Education*, (81), 735–747.

Suter, L. E., & Camilli, G. (2019). International Student Achievement Comparisons and US STEM Workforce Development. Journal of Science Education and Technology, 28(1), 52-61.

Suarez, A. V., & Tsutsui, N. D. (2004). The Value of Museum Collections for Research and Society. *BioScience*, 54(1), 66-74.

Unsworth, S. J., Levin, W., Bang, M., Washinawatok, K., Waxman, S. R., & Medin, D. L. (2012). Cultural Differences in Children's Ecological Reasoning and Psychological Closeness to Nature: Evidence from Menominee and European American Children. *Journal of Cognition and Culture*, *12*(1), 17–29. doi:10.1163/156853712X633901

Watkins, W. H. (2001). *The White architects of Black education: Ideology and power in America, 1865-1954*. Teachers College Press.

Witcomb, A. (2003). "A Place for All of Us"? Museums and Communities. In *Re-imagining the Museum: Beyond the Mausoleum* (pp. 79–101).

Witcomb, A. (2013). Understanding the role of affect in producing a critical pedagogy for history museums. Museum management and curatorship, 28(3), 255-271.

Worden, G. (2002). *Mütter museum of the college of physicians of Philadelphia*. Blast Books.

Yoon, S. a., Elinich, K., Wang, J., Steinmeier, C., & Tucker, S. (2012). Using augmented reality and knowledge-building scaffolds to improve learning in a science museum. *International Journal of Computer-Supported Collaborative Learning*, *7*(4), 519–541. doi:10.1007/s11412-012-9156-x

VITA

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EDUCATION

December 2019: University of Illinois at Chicago, Chicago, IL.
Anticipating awarded Doctorate of Philosophy in Curriculum and Instruction
Dissertation Title: 'Investigating Informal STEM Teaching and Learning in a Science Museum's Urban Youth
Leadership Program.'
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May 2010: Southern Illinois University, Carbondale, IL.
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June 2008: University of Oregon, Eugene, OR.
Awarded Bachelors of Arts in Medieval Studies, with Honors.
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Minors in Arts Administration, English, and Anthropology.

RESEARCH AND PROFESSIONAL EXPERIENCE

January 2019-ongoing: Director of STEAM and Innovation at Boy Scouts of America

Hired and managed educators and paraprofessionals for programs. Designed and managed programs in STEAM. Responsible for partnerships and growth in programs. Oversee merger of new STEAM program with both Explorers and traditional Cub Scouts. Wrote grants and managed events for fundraising. Represented BSA at both national and local conferences.

November 2017- January 2019: STEM Scout Director at Boy Scouts of America

Recruited and taught volunteer STEM teachers and assistant teachers. Conducted evaluations of student learning both locally and nationally. Worked closely with principals and teachers to start and maintain programming. Oversaw work with national and local human resources departments for paperwork and IRB.

August 2015-November 2017: STEM Scout Executive at Boy Scouts of America

Recruited and taught volunteer STEM teachers and assistant teachers. Conducted evaluations of student learning both locally and nationally. Worked closely with principals and teachers to start and maintain programming. Designed programming based on STEM. Wrote NGSS standard curriculum for elementary, middle, and high school students. Managed and recruited volunteer teams from multiple universities.

April 2014-August 2015: Evaluator at Science Museum

Designed, developed, and implemented audience research plan using in-depth interviews and in-person and online surveys. Conducted in-depth interviews with teachers and students

.Co-wrote final reports with The Science Museum staff. Authored IRB.

August 2014-March 2015: Measurement and Documentation Manager at Urban Gateways

Designed, developed, and implemented audience research plan using interviews, surveys, and in-class observations of artists and students. Composed reports and grants. Garnered over $50,000 in grant funds. Presented findings for both interior and exterior knowledge. Documented student performances through both film and photography.

August 2012 – August 2013: Research Assistant at the University of Illinois at Urban Area CoCensus Project:

Researched programming and outreach analysis. Interviewed participants. Transcribed interviews with participants and analyzed qualitative data. Designed docent teaching materials and collaborated with curators and consultants in design.

September 2005-June 2006: Research Assistant/Curatorial Intern at Erlandson Lab and Museum of Natural and Cultural History

San Miguel Coastal Archaeology Project:

Analyzing shell-midden materials from San Miguel National Reserve, compiling spreadsheet, illustrating materials, preserving materials, cataloging artifacts.

TEACHING EXPERIENCE

May 2015-ongoing: STEM Educator at iFLY, Naperville, IL

August 2013-August 2014- Manager of Education and Events, International Museum of Surgical Science, Chicago, IL

April 2012-August 2012- Youth and Family Programs Instructor, Pacific Science Center, Seattle, WA

August 2011-March 2012- Education Coordinator and Lead Educator, Coos Historical and Maritime Museum, North Bend, OR

January 2010-December 2010- Education Intern and Lead Educator, Lubbock Lake Landmark, Lubbock, TX

May 2009-December 2009- Museum and Arts Educator, Southern Illinois University, Carbondale, IL

March-June 2008- Assistant Arts Teacher, Jordan Schnitzer Museum of Art/Edison Elementary School, Eugene, OR

September 2007-July 2008- White Water Kayaking Instructor and Outing Leader, University of Oregon Outdoor Program, Eugene, OR

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March 2019 - Chicago Learning Exchange Event Fund ($100 received)
September 2018 - Masonic Foundation ($10,000 Received)
September 2018- ASHRAE Organization ($475 Received)
September 2018 - Bemis Foundation ($600 Received)
September 2018 - Kinder Morgan Foundation ($2,500 Received)
May 2018 - UIC University Support for ComSciCon ($5,000 received)
May 2018 - University of Chicago Support for ComSciCon ($5,000 received)
March 2018 - Story Collider Foundation Support for ComSciCon ($2,000 received)
September 2016 - Rivers Casino Foundation ($7,500 Received)
February 2015 - Fry Foundation ($30,000 Received)
December 2014 - Exelon Corporation ($25,000 Received)
November 2014 - Leo S. Guthman Fund ($15,000 Received)
November 2014- NSF Grant, ($2.3 million, Applied)

PUBLISHED BOOKS:

STEM Scouts Guide Book, Junior Level, 3rd Edition, co-authored with David McKeehan, April McMillan, Trent Nichols and Heather Shepard, published by Boy Scouts of America Press, Charlotte, NC, 2017.

STEM Scouts Guide Book, Technology Level, 3rd Edition, co-authored with David McKeehan, April McMillan, Trent Nichols and Heather Shepard, published by Boy Scouts of America Press, Charlotte, NC, 2017.

STEM Scouts Guide Book, Research Level, 3rd Edition, co-authored with David McKeehan, April McMillan, Trent Nichols and Heather Shepard, published by Boy Scouts of America Press, Charlotte, NC, 2017.

STEM Scouts Guide Book, Junior Level, 2nd Edition, co-authored with David McKeehan, April McMillan, Trent Nichols and Heather Shepard, published by Boy Scouts of America Press, Charlotte, NC, 2016.

STEM Scouts Guide Book, Technology Level, 2nd Edition, co-authored with David McKeehan, April McMillan, Trent Nichols and Heather Shepard, published by Boy Scouts of America Press, Charlotte, NC, 2016.

STEM Scouts Guide Book, Research Level, 2nd Edition, co-authored with David McKeehan, April McMillan, Trent Nichols and Heather Shepard, published by Boy Scouts of America Press, Charlotte, NC, 2016.

BOOK CHAPTERS/ARTICLES:

Vogt Veggeberg, K. 2019, ‘How Personal Experiences of Teachers Affects Minority Science Education’, *Paths to the Future of Higher Education,* Information Age Publishing (In Proceedings)

Vogt Veggeberg, K. 2019, ‘The role of museums in historical education in urban environments’, *Graduate Special Interest Groups’ Anthology of Urban Education*, The College of Education, University of Illinois at Urban Area (In Proceedings)

Vogt Veggeberg, K. 2017, ‘Review of A Curriculum of Fear: Homeland Security in U.S. Public Schools by Nicole Nguyen.’ *Anthropology and Education Quarterly*, Volume 48, Issue 1

Vogt Veggeberg, K. 2016, ‘History and Science at the Bakken Museum’, *The Watermark: Newsletter of the Archivists and Librarians in the History of the Health Sciences,* Number 3 (Summer 2016), pp 28-30

Vogt, K., 2011 ‘Can a University Museum Serve as a Community Museum as well?’ *Museum Education Monitor*, Winter 2011 issue, Vol.3

INVITED PRESENTATIONS:

STEAM in Scouting, IGNITE Talk, Homewood Science Center, September 18th, 2019

STEM and Citizen Science, Teen Conservation Leadership Conference, Dominican University, July 30th, 2019

Get Me a Job, Dang It!: How to Get Employed in Science Communication, ComSciCon, University of California San Diego, July 12th, 2019

Stacking Papers and Getting Paid: The Business Side of Science Communication, ComSciCon, University of California San Diego, July 12th, 2019

Citizen Science for the 21st Century, Citizen Science High School Fair, Wheeling High School, April 12th, 2019

How to Teach Archaeology as a STEM Subject, STEM Summit 2018, Northwestern University, October 24th, 2018

Collaboration between Medical Museums, and Boy and Girl Scouts, Oral Presentation at the American Medical Library Association and Medical Museum Association Conference, University of Minnesota, April 29th, 2016

STEM Education and the Informal Classroom, Oral Presentation at Going Off(shore): A Learning Symposium, the School of the Art Institute, April 9th, 2016

The Representation of Historic Feminism in Science Museums, Lecture at the University of Illinois at Urban Area, September 18th, 2015

Interpreting the Art of Curating: How an Art School Presented at a Medical Museum, Oral Presentation at the American Medical Library Association and Medical Museum Association Conference, Yale University, April 30th, 2015

How can learning effectiveness in Science Museums be measured using an online journal?, Oral Presentation at the Curriculum Studies Symposium, University of Illinois at Urban Area School of Medicine, February 20th, 2015

Managing the Medicine at the Museum, Oral Presentation at the Illinois Museum Association Conference, Burpee Museum of Natural History, October 21st, 2014

How Does an Inquiry Game Help Museum Visitor Learn Medical Vocabulary? Oral Presentation at the Curriculum Studies Symposium, University of Illinois at Urban Area School of Medicine, February 20th , 2014

PAPERS AS CONFERENCE PRESENTATIONS:

Vogt Veggeberg, K and Maktoufi, R. 2019, 'Social Emotional Learning in an After-School Setting With a STEM Program in Scouting', *In Proceedings of the 103rd conference of the American Educational Research Association* (AERA,'19)

Vogt Veggeberg, K. 2018, 'The Use of Human Remains in Science Museum Education', *In proceedings of the 78th conference for the Society for Applied Anthropology (SFAA '18)*

Vogt Veggeberg, K. 2017. 'Talking and Watching: The Exploration of Different Research Methodologies in Informal Science Education in Urban Area Museums' *In proceedings of the 116th Annual Conference for the American Anthropology Association (AAA, '17)*

Vogt Veggeberg, K. 2017. 'Changing Pathways: Applying Anthropologists Experiences to Work with Nonprofit Youth Programs' *In proceedings of the 116th Annual Conference for the American Anthropology Association (AAA, '17)*

Vogt Veggeberg, K. 2017, 'Can online digital archives replace hands-on learning? A reflection' *In proceedings of the 12th annual meeting of the Urban Area Colloquium on Digital Humanities and Computer Science (DHCS, '17)*

Vogt Veggeberg, K. 2016, 'The History of Control and Power within Urban Curriculum Studies'. *In proceedings of the 23rd International Conference on Learning and the Learner.*

Vogt Veggeberg, K. 2016, 'Understanding the Role of Feminism in the Design of Science Museums', *In proceedings of the 14th International Conference on New Directions in the Humanities and the New Directions in the Humanities.*

Vogt Veggeberg, K. 2016 'The Effects of a Leadership Corps on Urban Youth Science Interpretation' *In proceedings of the 18th Annual Urban Area Ethnography Conference (CEC '16)*

Vogt, K. 2016, 'How Personal Experiences of Teachers Affects Minority Science Education' *In proceedings of the 76th conference for the Society for Applied Anthropology (SFAA '16)*

Vogt, K. 2016, ‘How Personal Experiences of Teachers Affects Minority Science Education’, *In proceeding of the 182nd conference for the American Association for Advancements in Science (AAAS ‘16)*

Vogt, K. 2015, ‘Revisiting ‘Black Metropolis’ in the 21st Century’ *In Proceedings of the 38th Annual Mid-Western Educational Research Association Conference* (MWERA, ‘15)

Vogt, K. 2015, ‘How can learning effectiveness in Science Museums be measured using an online journal?’ *In proceedings of the 28th Annual Visitor Studies Association Conference* (VSA, ‘15)

Vogt, K. 2015, ‘The Impact of a Design Arts Residency in an Urban Elementary School’, *In Proceedings of the 14th conference for the American Association of the Advancement of Curriculum Studies* (AAACS, ‘15)

Cafaro, F., Kang, R., Lyons, L., Roberts, J., Radinsky, J., Vogt, K., ‘Framed guessability: using embodied allegories to increase user agreement on gesture sets’ *In Proceedings of the 8th International Conference on Tangible, Embedded and Embodied Interaction* (TEI, ‘14)

Vogt, K. 2014 ‘How does peer interaction effect independent learning in a medical museum?’ *In Proceedings of the 113th conference for the American Anthropology Association* (AAA, ‘14)

Vogt, K.,2014 ‘The Role of Identity as a Learning Tool in Museum Exhibits’, *In Proceedings of the 5th international conference for the Inclusive Museum* (IMC, ’14).

Lyons, L., Cafaro, F., Roberts, J., Radinsky, J., Vogt, K., ‘Scaffolding Self-Directed Learning in Technology-Enhanced Environments’ *In Proceedings of the 98th conference of the American Educational Research Association* (AERA, ‘14)

Vogt, K., 2014 ‘The Benefits of Teacher-Lead Inquiry in a Census Data Exhibit’, *In Proceedings of the 180th international conference on American Association for Advancements in Science* (AAAS ‘14)

Roberts, J., Cafaro, F., Kang, R., Vogt, K., Lyons, L., Radinsky, J., 2013. ‘That’s Me and That’s You: Museum visitors’ perspective-taking around an embodied interaction data map display’. *In Proceedings of the 10th international conference on Computer Supported Collaborative Learning* (CSCL'13)

MAINSTREAM PUBLICATIONS:

Vogt Veggeberg, K. ‘There’s physics behind shifting tombstones that has nothing to do with ghosts’, *Lab Notes*, Massive Science, October 29th, 2019

Vogt Veggeberg, K. ‘Why Every NVLD Individual Should Take Up Cycling,’ September 26th, *The NVLD Project*, 2019

Vogt Veggeberg, K. ‘The Importance of STEM Education, The Museum, and Evolving Society’. *Informal Science*, The Center for the Advancement of Informal Science Education, June 25th, 2019

Vogt Veggeberg, K. ‘The 10 Commandments of AERA (and other large academic conferences in general)’, *Medium*, April 23rd, 2019

Vogt Veggeberg, K, ‘The Science of Grilling vs. Barbecue’, *Science UnSealed,* October 1, 2018

Vogt Veggeberg, K, ‘Getting Clean with Some Household Science’, *Science UnSealed,* August 13, 2018

Vogt Veggeberg, K, 2018, “A Bridge Too Far Burned, or How to Deal with a Colleague’s Rejection,” *Medium*, July 18th, 2018

Vogt Veggeberg, K, ‘The Science of Laundry’, *Science UnSealed,* May 31, 2018

Vogt Veggeberg, K, ‘The Citizen Scientist’, *Science UnSealed,* April 16, 2018

Vogt Veggeberg, K, ‘Knitting: For Senior Citizens or Scientists?’ *Science UnSealed*, February 19, 2018

Vogt, K.,‘Time Management as a Full Time Ph.D’, *Recess Blog,* University of Illinois at Urban Area College of Education, Fall 2013.

HONORS AND AWARDS

February 2019—UIC Travel Grant, American Educational Research Association
January 2019—Dissertation Editing Grant, College of Education, University of Illinois at Chicago
April 2018—ComSciCon National Participant, MIT/Harvard University
March 2018—UIC Travel Grant, Society for Applied Anthropology
November 2017—Chief’s Growth Challenge 2017 Achiever, Boy Scouts of America
November 2016—Chief’s Growth Challenge 2016 Achiever, Boy Scouts of America
April 2016—UIC Travel Grant, Medical Museums Association
March 2016—Del Jones Award, Society for Applied Anthropology
October 2014—UIC Travel Grant, American Anthropology Association
May 2014—Graduate Scholar Award, Inclusive Museum Conference
January 2014—August 2014—University of Illinois at Chicago College of Education Tuition Waiver
Scholarship
August 2012—August 2013—University of Illinois at Chicago Graduate College Tuition Waiver
March 2012—Segal AmeriCorps Education Award
August 2010—Mountain-Plains Museum Association Scholarship Winner
March 2010—ISEA Scholarship Winner
January 2008—Southern Illinois University Graduate School Scholarship Winner

August 2008—Southern Illinois University Graduate School Scholarship Winner
June 2008—Graduated with Departmental Honors, University of Oregon
December 2006—Inducted into Phi Alpha Theta Honors Society
May 2005 – December 2006: Dean's List, University of Oregon
June 2004— Young Urban Area Author's Scholarship
June 2004—William Henry Smith Prose Award
June 2004—William Henry Smith Poetry Award
June 2003—William Henry Smith Poetry Award
May 2002—Pullman Historical Society Essay, 1st Place

MEMBERSHIPS:
American Education Research Association
Society for Applied Anthropology
Boy Scouts of America
Associate's Board of the Oriental Institute, University of Chicago

LEADERSHIP:

Associate Board of the Oriental Institute of the University of Urban Area, 2018-ongoing
The Society for Applied Anthropology, Advisory Board for the Topical Interest Group on Higher Education, 2017-ongoing
Illinois Science Council, Associate Board, 2017-ongoing
ComSciCon Organizational Committee Member, 2016- 2019
Student Representative, Graduate Student Council of UIC, 2015-2016
Secretary/Treasurer of the Medical Museum Association, 2014-2016
Conference Chair of the Midwestern Education Research Association, 2015
Conference Chair of the Inclusive Museum Conference, 2014

REVIEWING EXPERIENCE:

August 2016-ongoing: The Learner Journal
July 2015-ongoing: Mid-Western Education Research Association
May 2015-ongoing: American Education Research Association
March 2014-ongoing: American Anthropological Association

COMMUNITY VOLUNTEERING:

April 2016-ongoing: Urban Area Learning Exchange, member
April 2015-ongoing: Hal Tyrell Trailside Museum, volunteer educator and crew member
May 2013- ongoing: Urban Area Cultural Researcher Network, member
January 2013-ongoing: Urban Area Metropolitan History Fair, Judge
September 2011-May 2012: Girl Scouts of Southwestern Washington and Oregon, Troop Leader
August 2011-March 2012: Oregon State Service Corps, Americorps Service Member
January 2010-December 2010: Lubbock Mental Health Center, Art Teacher

COMPETENCIES & INTERESTS

Administration: Museum Administration, teacher management, project management, grant writing, volunteer management, operations management, and other administration duties.
Technology: Expert in Microsoft Office, Adobe Photoshop, NVivo, InqScribe, Max QDA, and STRATA.
Languages: English (Native), French (Intermediate), German (novice), JavaScript (novice), SQL (Intermediate)
Arts Ability: Expert in fiber arts (drop-needle and machine spin, knitting, hand-quilting, and sewing), Japanese watercolors, and sketching.